Service

Marine Generator Sets

Models:

5EKD/4EFKD–Low CO
7.5EKD/6EFKD–Low CO
10EKD/8EFKD–Low CO

Controller:
Advanced Digital Control II

ISO 9001
KOHLER POWER SYSTEMS
NATIONALLY REGISTERED

KOHLER®
Power Systems

TP-6593 10/13b

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IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

⚠ DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

⚠ WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

⚠ CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

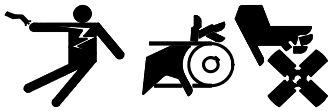
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the backfire flame arrester. A sudden backfire can cause severe injury or death. Do not operate the generator set with the backfire flame arrester removed.

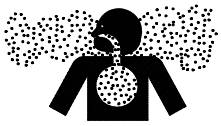
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner removed.

Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the generator set. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Catch fuels in an approved container. Wipe up spilled fuels and engine oil.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

⚠ WARNING

Explosion.
Gasoline vapors can cause explosion and severe injury or death.

Before starting the generator set, operate the blower 4 minutes and check the engine compartment for gasoline vapors.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Ignition-protected equipment. Explosive fuel vapors can cause severe injury or death. Gasoline vapors can cause an explosion. USCG Regulation 33CFR183 requires that all electrical devices (ship-to-shore transfer switch, remote start panel, etc.) must be ignition protected when used in a gasoline and gaseous-fueled environment.

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Hazardous Voltage/ Moving Parts

⚠ WARNING

Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is turned off. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

Hot Parts

⚠ WARNING

Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

Notice

NOTICE

Fuse replacement. Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Notes

This manual provides troubleshooting and repair instructions for the generator set models listed on the front cover.

For engine service procedures not covered in this manual, refer to the Engine Service Manual listed below.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.

Tech Tools

Access the TechTools site to find the following topics:

- **Software** used by generator set controllers including updates and documentation references.
- **Network Communications** provides basics to terms, protocols, standards, wiring, configurations, and model.
- **Engine Electronic Control Module (ECM)** has information about electronic devices provided by the engine manufacturer to manage engine data.

List of Related Materials

Separate manuals contain operation, installation, and parts information not provided in this manual. Separate engine Operation and Service manuals are also available. The following table lists the available manual part numbers.

Literature Type	Part Number
Installation Manual	TP-6592
Operation Manual (Generator)	TP-6591
Operation Manual (Engine)	66 590 02
Parts Catalog*	TP-6594
Service Manual (Generator)	TP-6593
Service Manual (Engine)	66 690 01

* One manual combines Generator and Engine information.

Figure 1 Generator Set Literature

Routine Service Parts

The following table contains part numbers for recommended spare parts. Contact your Kohler generator distributor/dealer for a complete list of service parts for your generator set or for models or spec numbers not listed.

Part Description	Part Number
Backfire flame arrestor	GM24212
Fuel filter	267987
Fuse, (F1) 10 amp, Customer connection	GM42337
Fuse, (F2) 25 amp, Voltage regulator	GM42339
Fuse, (F3) 20 amp, Injector, CO sensor, fuel pumps, oxygen sensor, and coils	GM47427
Fuse, (F4) 10 amp, Controller	GM42337
Fuse, (F5) 10 amp, Auxiliary winding	358337
Oil filter	52 050 02-S
Seawater pump impeller kit	359978
Seawater pump belt	GM53040
Engine cooling pump belt	66 203 01-S
Spark plug	25 132 16-S
Spray paint (Matterhorn white)	GM48126
Zinc anode	260085

Figure 2 Maintenance and Service Parts

Service Assistance

For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric
- Visit the Kohler Power Systems website at KOHLERPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product
- Call toll free in the US and Canada 1-800-544-2444
- Outside the US and Canada, call the nearest regional office

Headquarters Europe, Middle East, Africa (EMEA)
Kohler Power Systems Netherlands B.V.
Kristallaan 1
4761 ZC Zevenbergen
The Netherlands
Phone: (31) 168 331630
Fax: (31) 168 331631

Asia Pacific
Power Systems Asia Pacific Regional Office
Singapore, Republic of Singapore
Phone: (65) 6264-6422
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China
North China Regional Office, Beijing
Phone: (86) 10 6518 7950
(86) 10 6518 7951
(86) 10 6518 7952
Fax: (86) 10 6518 7955

East China Regional Office, Shanghai
Phone: (86) 21 6288 0500
Fax: (86) 21 6288 0550

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80 3366208
(91) 80 3366231
Fax: (91) 80 3315972

Japan, Korea
North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, USA
Phone: (863) 619-7568
Fax: (863) 701-7131

1.1 Introduction

The spec sheets for each generator set provide specific generator and engine information. Refer to the generator set spec sheet for data not supplied in this manual. Consult the generator set installation manual, engine operation manual, and engine service manual for additional specifications.

1.2 Generator Set Ratings

See the generator set ratings in Figure 1-1. Consult generator set nameplate for specific generator set ratings.

1.3 Controller Specifications

The generator set is equipped with the Advanced Digital Control II. For a specific description of the controller, see Section 2, Operation, in the operation manual.

Environmental Specification	ADC II
Operating temperature	-20° to 70°C (-4° to 158°F)
Humidity	5-95% non-condensing
Power requirements:	
Voltage	12 VDC
Current draw, max.	250 mA @ 12 VDC

Model Series	Alternator	Voltage	Ph	Hz	25°C (77°F) Amps	25°C (77°F) kW/kVA
5EKD	2F2	120	1	60	41.7	5/5
		120/240			20.8	5/5
4EFKD	2F2	115/230	1	50	17.4	4/4
		230			17.4	4/4
		240			16.7	4/4
7.5EKD	2F3	120	1	60	62.5	7.5/7.5
		120/240			31.3	7.5/7.5
6EFKD	2F3	115/230	1	50	26.1	6/6
		230			26.1	6/6
		240			25.0	6/6
10EKD	2F4	120	1	60	83.3	10/10
		120/240			41.7	10/10
8EFKD	2F4	115/230	1	50	34.8	8/8
		230			34.8	8/8
		240			33.3	8/8
RATINGS: Marine continuous ratings per ISO 3046, ISO 8528-1, and Kohler ISO rating guideline 2.14. Obtain technical information bulletin (TIB-101) on ratings guidelines for complete ratings definitions.						

Figure 1-1 Generator Set Ratings

1.4 Alternator Specifications

Alternator Specification	5EKD/4EFKD	7.5EKD/6EFKD	10EKD/8EFKD
Alternator model	2F2	2F3	2F4
Stator leads, qty.	4	4	4
Phase	1	1	1
Rotor resistance, ohms, cold	3.4	3.4	4.0
Stator resistance, ohms,* cold			
Main winding: 1-2, 3-4	0.16	0.16	0.07
Aux. winding: 55-66	1.70	1.70	0.35
Stator output voltage with separately excited rotor using 12-volt battery, minimum			
Main winding: 1-2, 3-4, volts	150	150	130
Aux. winding: 55-66, volts	190	190	170
Rotor field voltage/current readings at rated output voltage, hot			
No load, volts/amps	11/2.4	11/2.4	13/2.4
Full load, volts/amps	35/7	47/9	55/8

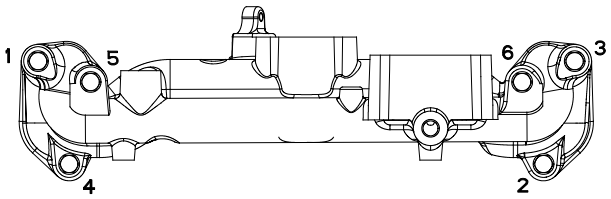
* Most ohmmeters do not give accurate readings when measuring less than 1 ohm. The stator can be considered good if a low resistance reading (continuity) is obtained and there is no evidence of shorted windings (discoloration). Do not confuse a low resistance reading with a reading indicating a shorted winding.

1.5 Alternator Specifications, Continued

Alternator Specification	5/7.5/10EKD 4/6/8EFKD
Frequency Hz	60/50 Hz
Excitation method	Brush type
Voltage regulator type	Digital/Analog
Winding material	Class H
Bearing, quantity and type	1 sealed
Circuit protection	
Customer connection (F1)	10 amp fuse
Voltage regulator (F2)	25 amp fuse
Injector, CO sensor, fuel pumps, oxygen sensor, and coils (F3)	20 amp fuse
Controller (F4)	10 amp fuse
Auxiliary winding (F5)	10 amp fuse
Brush length, new	1.9 cm (0.75 in.)

1.6 Torque Specifications

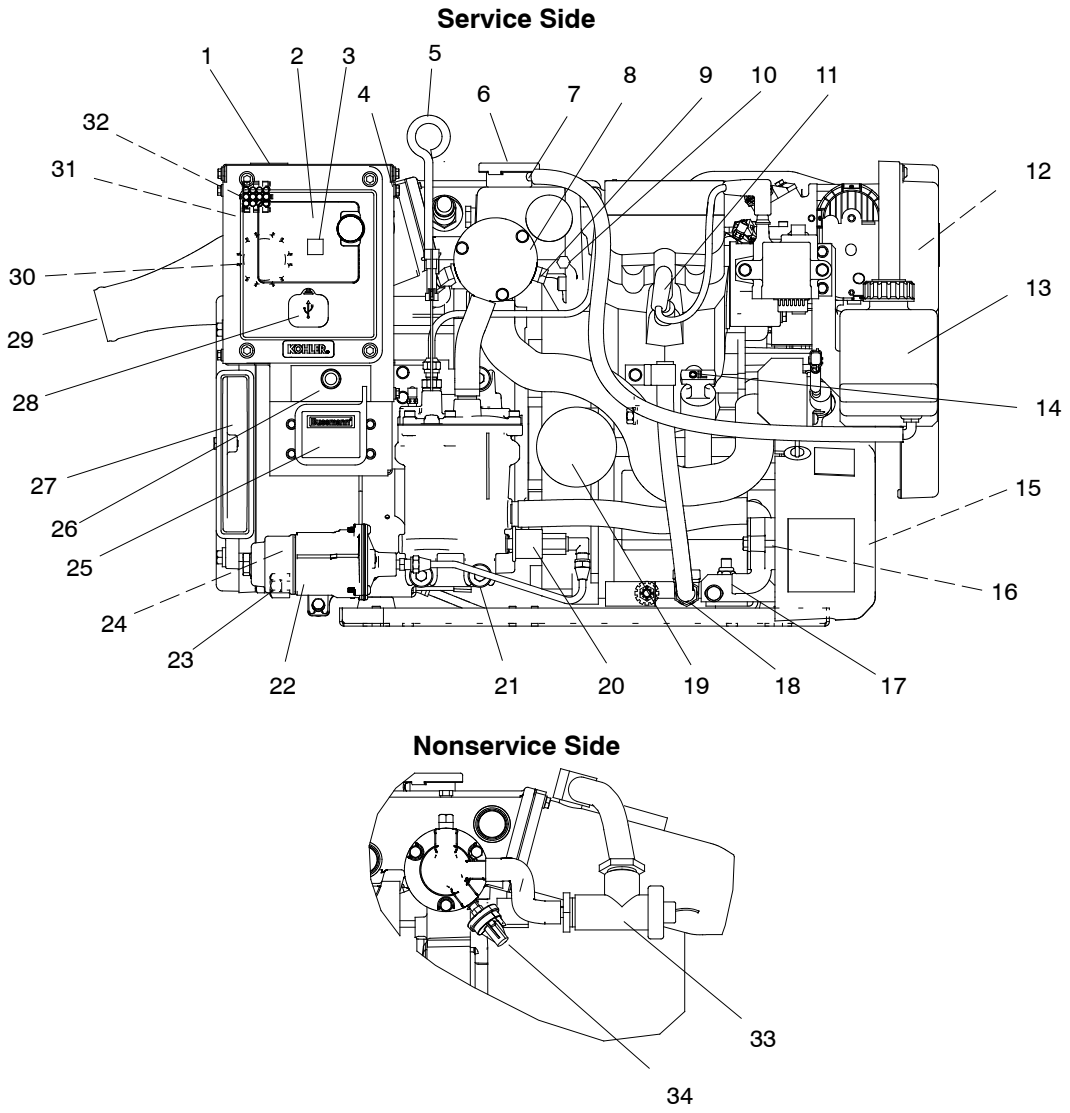
Follow the general torque specification found in Appendix C of this manual unless noted below or provided in the Engine Service Manual.

Torque Specifications	5/7.5/10EKD 4/6/8EFKD
Rotor thru-bolt 5/7.5EKD and 4/6EFKD 10EKD and 8EFKD	 23 Nm (204 in. lbs.) 32.5 Nm (288 in. lbs.)
Generator overbolts	13 Nm (120 in. lbs.)
Lifting eye bolts	7.3 Nm (65 in. lbs.)
Generator adapter to engine bolts	15 Nm (132 in. lbs.)
Spark plugs	24.4–29.8 Nm (18–22 ft. lbs.)
Intake manifold to engine	Tighten all hardware in the sequence shown in two steps: first to 7.4 Nm (66 in. lbs.) then to 9.9 Nm (88 in. lbs.)
	
Catalyst assembly	9.5 Nm (7 ft. lbs.)
Thermostat cover	9.9 Nm (88 in. lbs.)
Starter motor mounting bolts	15.3 Nm (135 in. lbs.)
Exhaust manifold center mounting bolt to adapter	11 Nm (8 ft. lbs.)
Exhaust manifold to engine (4 bolts)	24.4 Nm (18 ft. lbs.)
End bracket plate to alternator housing	7 Nm (60 in. lbs.)

1.7 Engine Specifications

Engine Specification	5/7.5/10EKD 4/6/8EFKD	
Manufacturer	Kohler	
Model	LH690	
Cycle	4	
Number of cylinders	2	
Compression ratio	8.5:1	
Displacement, L (cu. in.)	0.674 (41.1)	
Max. power at rated rpm, HP	18.9	15.8
Rpm	3600	3000
Bore x stroke, mm (in.)	80 x 67 (3.15 x 2.64)	
Cylinder head material	Aluminum	
Cylinder block material	Aluminum	
Piston rings	2 compression/1 oil	
Piston material	Aluminum	
Crankshaft material	Hardened steel	
Crankshaft bearings, type	Inserts	
Governor, type	Electronic	
Lubrication system	Pressure	
Oil capacity (w/filter), L (qt.)	1.9 (2.0)	
Oil pressure, kPa (psi)	276 (40)	
Oil recommendation (API)	SJ or higher	
Fuel system, type	Throttle-body fuel injected	
Battery charging alternator	25 amps	
Battery voltage	12 VDC	
Battery ground	Negative	
Battery recommendation, minimum	250 CCA	
Spark plug gap, mm (in.)	0.76 (0.030)	
Ignition system	Inductive	
Starter motor	Bendix automotive type	
Cooling system	Water-cooled	

1.8 Service View

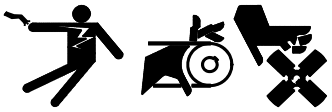


1. Nameplate (top)
2. Advanced Digital Control II
3. Generator set start/stop button
4. AC circuit breaker
5. Optional lifting eye tool
6. Pressure cap (coolant fill location after draining coolant)
7. Overflow tube
8. Heat exchanger
9. Anticorrosion zinc anode (seawater drain)
10. Coolant drain
11. Spark plug (also one located on the nonservice side)
12. Air intake silencer/backfire flame arrestor
13. Coolant overflow bottle (daily coolant check/fill location)
14. Oil fill/check
15. V-belt
16. Seawater pump
17. Seawater inlet
18. Oil drain valve
19. Lube oil filter
20. Fuel filter
21. Fuel pump/cooler
22. Fuel pump
23. Fuel inlet
24. Filter screen
25. Fuse block (F1, F2, F3, and F4)
26. Fuse F5
27. Cooling air inlet
28. USB connection
29. Catalyst assembly, water outlet/exhaust outlet (nonservice side)
30. AC load lead connector (nonservice side)
31. CO sensor module (inside junction box)
32. Customer interface connection (nonservice side)
33. Seawater flow switch (nonservice side)
34. Seawater pressure switch (nonservice side)

Note: Consult installation drawings in Spec Sheet or Installation Manual for fuel- and battery-connection points.

Figure 1-2 Service Views

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Alternator Service. Under normal operating conditions the generator set alternator does not require scheduled service. Refer to the service schedule for items that require maintenance.

Engine Service. Perform generator set engine service at the intervals specified by the engine service literature. Contact an authorized Kohler® service distributor/ dealer to obtain engine service literature.

Generator Set Service. See the Safety Precautions and Instructions at the beginning of this manual before attempting to service, repair, or operate the generator set. Have an authorized Kohler® service distributor/ dealer perform all generator service.

Routine Maintenance. Refer to the following generator set service schedule, the engine service schedule, and the runtime hours displayed on the ADC II to determine when to schedule routine maintenance. Service the generator set more frequently if it is subject to extreme weather, long operating hours, or dusty or dirty conditions.

Service Schedule. Perform maintenance on each item in the service schedule at the designated interval for the life of the generator set.

Tools. Tools and instruments used to perform some maintenance items are not generally available to the generator set owner. Therefore, have service performed by an authorized distributor/dealer.

2.1 General

Perform the items listed in the service schedule at the designated intervals for the life of the generator set. For example, an item serviced every 100 hours or 3 months must also be serviced after 200 hours or 6 months, 300 hours or 9 months, etc.

Note: See the generator set operation manual and the engine service manual for service procedures not included in this manual.

2.2 Service Schedule

Perform Service at Intervals Indicated (X)	Before Starting	After 50 Hr or 1 Month	Every 100 Hr or 3 Months	Every 300 Hr or 6 Months	Every 500 Hr or Yearly
Fuel System					
Check the fuel level and fill as necessary	X				
Check fuel lines and replace as necessary *†				X	
Replace the fuel filter *†					X
Lubrication System					
Check crankcase oil level and add as necessary	X				
Replace the oil in crankcase *			X (200 hr)		
Replace the lube oil filter element *			X (200 hr)		
Cooling System					
Check coolant level and fill as necessary *	X				
Check seawater outlet and clean as necessary †	X (during operation)				
Check function of siphon break, if equipped			X		
Check and clean seawater flow switch *			X		
Replace seawater pump impeller *†				X (check)	X
Adjust seawater pump tension *†				X (200 hr)	X
Check heat exchanger anticorrosion zinc condition *			X		
Replace heat exchanger anticorrosion zinc *					X
Flush cooling system *†					X (1000 hr/ 2 years)
Ignition System					
Check spark plugs condition and gap *			X		
Replace spark plugs *				X (250 hr)	
Intake/Exhaust System					
Inspect exhaust system components *†	X				
Check the exhaust gas condition	X (during operation)				
Service backfire flame arrestor *			X		
Check and/or replace the catalyst assembly *†					X
Replace the CO sensor module *†					X (every 2 years)
Check the crankcase breather pipe for obstructions *†				X	
Inspect the complete exhaust system ***					X
Electrical System					
Keep battery charged and in good condition ⊕	X				
Check and tighten electrical connections *		X			
Clean battery cables †			X (200 hr)		
Engine And Mounting					
Check for water, fuel, coolant, and oil leakage *†‡	X				
Retighten all nuts and bolts *	X				
Check tightness of mounting bolts/vibromounts *			X (200 hr)		
Remote Control System					
Check remote control operation		X (break-in period)			X
Generator					
Test run generator set		X (weekly)			
Blow dust out of generator *†					X
Clean slip rings and inspect brushes *†					X (1000 hr.)

* Requires removal of sound shield, if installed.
† Consult your local distributor/dealer for service.
‡ Read WARNING found at the beginning of manual regarding moving parts.
*** Should be performed by your local distributor/dealer.
⊕ Consult battery manufacturer's instructions.

3.1 Introduction

Corrective action and testing in many cases requires knowledge of electrical systems and electronic circuits. Have an authorized distributor/dealer or trained service technician perform testing and service.

Refer to the Engine Service Manual, 66 690 01, for engine service information.

The first step in troubleshooting the generator set controls is to verify that the controller is correctly configured for the generator set. The Generator Set Installation Manual explains how to check and change the controller configuration.

If the troubleshooting procedures in this section identify a bad part, refer to the parts catalog for replacement part numbers. See the List of Related Materials in the Introduction for the parts catalog number.

3.2 Initial Checks

When troubleshooting, always check for simple problems first. Check for the following common problems before replacing parts:

- **Loose connections or damaged wiring.**
- **Dead battery.**
- **Fault shutdown.** Check for a fault code on the ADC II display. Section 4.2.5 describes the warning and shutdown fault codes.
- **Blown fuses.** See Figure 3-1 for fuse identification. Always check and replace the fuses before replacing other components.

Schematic Diagram Fuse Reference Number	Location	Fuse	Amps	Part Number
F1	Fuse block, position 1	Customer connection	10	GM42337
F2	Fuse block, position 4	Voltage regulator	25	GM42339
F3	Fuse block, position 5	Injector, CO sensor, fuel pumps, oxygen sensor, and coils	20	GM47427
F4	Fuse block, position 8	Controller	10	GM42337
F5	Fuse holder	Auxiliary winding	10	358337

Figure 3-1 Fuse Identification

- **Incorrect controller settings.** *Always* check the controller configuration settings before replacing the controller. Section 4.7 explains how to check and change the controller settings.

3.3 Troubleshooting Chart

Use the following table(s) as a reference in troubleshooting individual problems. Generator set faults are listed in groups and include likely causes and remedies. The simplest and most likely causes of the problem are listed first; follow the recommendations in the order shown. The reference column provides additional sources of information in this and related manuals regarding the problem and solution.

Note: In the following table(s), O/M refers to the Operation Manual, I/M refers to the Installation Manual, and S/M refers to the Service Manual.

Troubleshooting Chart

Problem	Possible Cause	Corrective Action	Reference
Generator set does not crank	Weak or dead battery	Recharge or replace battery.	Generator O/M
	Battery connections	Check for reversed or poor battery connections.	—
	Open circuit in engine/controller connections	Check for loose connections. Check the wire harness continuity.	Section 7
	Blown fuse F4, controller	Replace fuse; if fuse blows again, check circuit and components.	Section 5.11 Section 7
	Crank relay	Check for 12VDC on lead 71N.	Section 7
		Check for a good ground connection (lead N).	Section 7
	Poor ground (–) connection	Clean and retighten.	—
	Starter	Check starter connections.	Section 7
		Rebuild or replace starter.	Engine S/M
	Controller	Check controller connections and operation. Check for power to the controller.	Section 4 Section 7
	Blown F3 fuse	Check the starter solenoid for a stuck solenoid. Check wiring for open grounds or loose connections. Also, check for pushed out pins.	Section 7
	Blown F4 fuse	Check the controller wiring. Check wiring for open grounds or loose connections. Also, check for pushed out pins.	Section 7
	Engine harnessing to throttle body not connected	Check the generator set harnessing to the throttle body and TMAP sensors. Check wiring for open grounds or loose connections. Also, check for pushed out pins.	Section 7
Cranks but does not start	No fuel	Check the fuel supply. Check the fuel filters for blockage.	—
	Spark plugs or spark plug connections	Check spark plug wires and connections. Replace or clean and regap spark plugs.	O/M
	Loose connection or open circuit	Check for loose or open connections at the fuel pumps and at the engine control module. Check controller/engine wiring continuity.	Section 7
	Backfire flame arrestor clogged	Clean or replace.	O/M
	Incorrect controller configuration	Check for correct controller configuration settings.	Section 4.7
	Ignition system spark control or ignition coil	Test and/or replace components.	Engine S/M
	No engine rotation sensed (check for an overcrank fault shutdown)	Check for locked rotor.	Section 5.4
Starts hard	Low battery voltage	Check battery voltage.	O/M
	Backfire flame arrestor clogged	Clean or replace.	O/M
	Spark plug(s)	Replace or regap spark plug(s).	O/M
	Spark plug wire(s)	Check spark plug wires and connections. Replace spark plug wires.	Engine S/M
	Ignition components (ignition coils)	Test/replace ignition components. Check the harnessing to these components for continuity.	Engine S/M
	Worn piston rings, valves	Check compression.	Engine S/M
	Blown F2 fuse	Check voltage regulator wiring.	Section 7
Starts but shuts down	Fault shutdown	Check for a fault shutdown code on the controller's display. Correct the fault and then reset the controller.	Section 4.2.5 Section 5.9

Problem	Possible Cause	Corrective Action	Reference
Stops suddenly	Fault shutdown	Check for a fault shutdown code on the controller's display. Correct the fault and then reset the controller.	Section 4.2.5 Section 5.9
	No fuel	Check the fuel supply.	—
	Fuel line restriction	Inspect fuel lines and fuel filters for blockage.	—
	Backfire flame clogged	Replace element.	O/M
	Blown controller fuse (F4)	Replace fuse. Check wiring to the controller.	Section 5.11
	Blown auxiliary winding fuse (F5)	Replace fuse. If fuse blows again, test generator components.	Section 5.11
	Blown voltage regulator fuse (F2)	Replace fuse. Troubleshoot the voltage regulator.	Section 5.11
	Spark plug(s)	Replace and regap plug(s).	Engine S/M
	Engine overheated (hot engine only)	Check air intake, fuel, oil level, air inlet/outlet.	O/M and I/M
	Low oil pressure (LOP) switch	Attempt startup. Shutdown should say "**Low oil pres**" if unit shuts down, remove lead from LOP switch and reset controller. A successful restart attempt indicates a faulty LOP shutdown switch. **Note:** Check engine oil pressure before performing test and/or replacing LOP shutdown switch.	Engine S/M
	Engine overloaded	Reduce electrical load. Shutdown on overload fault	I/M
	Loss of generator output voltage to controller	Check connections at P2 plug. Check continuity of AC sensing leads 11 and 44.	Section 7
	Intermittent wiring connections	Inspect fuel pump wiring to ensure good connections.	—
	Blown F3 fuse	Verify line circuit.	Section 7
	Blown F5 fuse	Troubleshoot rotor and stator assembly and wiring.	Section 7
Operates erratically	Backfire flame arrestor clogged	Clean or replace.	O/M
	Spark plug(s)	Replace and regap plugs.	O/M
	Spark plug wire(s)	Replace spark plug wires.	Engine S/M
	Fuel line restriction	Check fuel lines, filters, and pumps.	—
	Ignition system	Test and/or replace components.	Engine S/M
	Inadequate cooling (hot engine only)	Inspect air inlet and outlet.	—
	Carbon buildup in engine	Clean cylinder head.	Engine S/M
	Engine valves not seating correctly	Check cylinder pressures with leakdown test. Inspect valves and valve seats.	Engine S/M
Lacks power	Air intake restriction, inadequate cooling	Inspect air intakes and exhaust for obstructions. Check air cleaner.	—
	Generator overloaded	Reduce load.	—
	Spark plug(s)	Replace and regap plug(s).	O/M
	Spark plug wire(s)	Replace spark plug wires.	Engine S/M
	Engine not running at rated rpm	Check controller configuration setting.	Section 4.7
	Engine power loss	Refer to the Engine Service Manual for troubleshooting and repair instructions.	Engine S/M
	Ignition system	Test and/or replace. Check ignition coil wiring.	Engine S/M
Overheats	Inadequate cooling	Inspect cooling system for air intake obstructions. Check the engine coolant system for blockage and clean as necessary.	—
	Backfire flame arrestor clogged	Clean or replace.	O/M

Problem	Possible Cause	Corrective Action	Reference
Low output or excessive drop in voltage	Generator overloaded	Reduce load.	—
	Incorrect controller configuration	Check and adjust the controller configuration settings.	Section 4.7
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 4.7
	Alternator or control system	Perform separate excitation procedure to isolate problem to the alternator or the control system.	Section 5.2
	Intermittent wiring connection or lack of compression	Check harness connections. Check P2 plug and F5 fuse connections.	Section 5.11 Section 7
	Controller	Check controller settings. Check controller fuse, wiring and connections.	Section 4.7 Section 7
	Rotor (open, grounded, or shorted windings)	Test and/or replace.	Section 5.4
	Stator (open, grounded, or shorted windings)	Test and/or replace.	Section 5.3
	Brush connection	Check for loose brush connections. Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.	Section 5.6
Light flicker	Voltage stability (gain) setting	Check and adjust the voltage stability (gain) setting using the ADC II.	Section 4.7
High output voltage	Incorrect controller configuration	Check and adjust the controller configuration settings.	Section 4.7
	Incorrect controller voltage settings	Check and adjust the controller voltage settings.	Section 4.7
	Loose voltage sensing connections	Check connections: stator leads 11 and 44 and P2 controller connection.	Section 7
	Controller	Check fuses, wiring and connections.	Section 4
No output voltage	AC output circuit breaker open	Check for AC voltage on the generator side of circuit breaker. If there is AC voltage on the generator side of the breaker, then a problem in the load circuits is causing the line circuit breaker to trip. Check for and correct short circuits or overloading on the load side before resetting the circuit breaker.	—
	Alternator or control system	Perform separate excitation procedure to isolate the problem to the alternator or the control system. Then troubleshoot the alternator or control system components as follows.	Section 5.2
	Aux. winding F5 fuse blown	Replace blown fuse. If fuse blows again, check stator.	Section 5.3
	Controller	Check controller settings. Check wiring and connections.	Section 4.7 Section 4.6
	Open wiring, terminal, or pin in buildup circuit	Check continuity.	Section 5.12 Section 7
	Brushes	Inspect brushes and replace if worn.	Section 5.6
		Check for brushes sticking in brush holder or broken brush spring.	Section 5.6
	Rotor connections	Check for open circuit in rotor connection circuit (leads FN and FP).	Section 7
	Rotor slip rings dirty or corroded	Check slip ring condition.	Section 5.4
	Rotor (open, grounded, or shorted windings)	Check voltage and continuity.	Section 5.4
	Stator (open, grounded, or shorted windings)	Check voltage and continuity.	Section 5.3

Problem	Possible Cause	Corrective Action	Reference
Noisy operation	Exhaust system leaks	Check and replace as necessary.	O/M
	Engine not running smoothly	See “Generator set operates erratically,” this table.	—
	Broken or damaged vibromount(s)	Check and replace as necessary.	—
	Loose or vibrating sheet metal/housing	Retighten screws, replace rivets.	—
	Exhaust piping or air inlets/outlets not securely installed	Inspect for loose parts and secure if necessary.	—
	Excessive engine/generator vibration	Check, rotor, crankshaft, bearing, etc. (disassembly of engine and/or alternator may be required).	Engine S/M

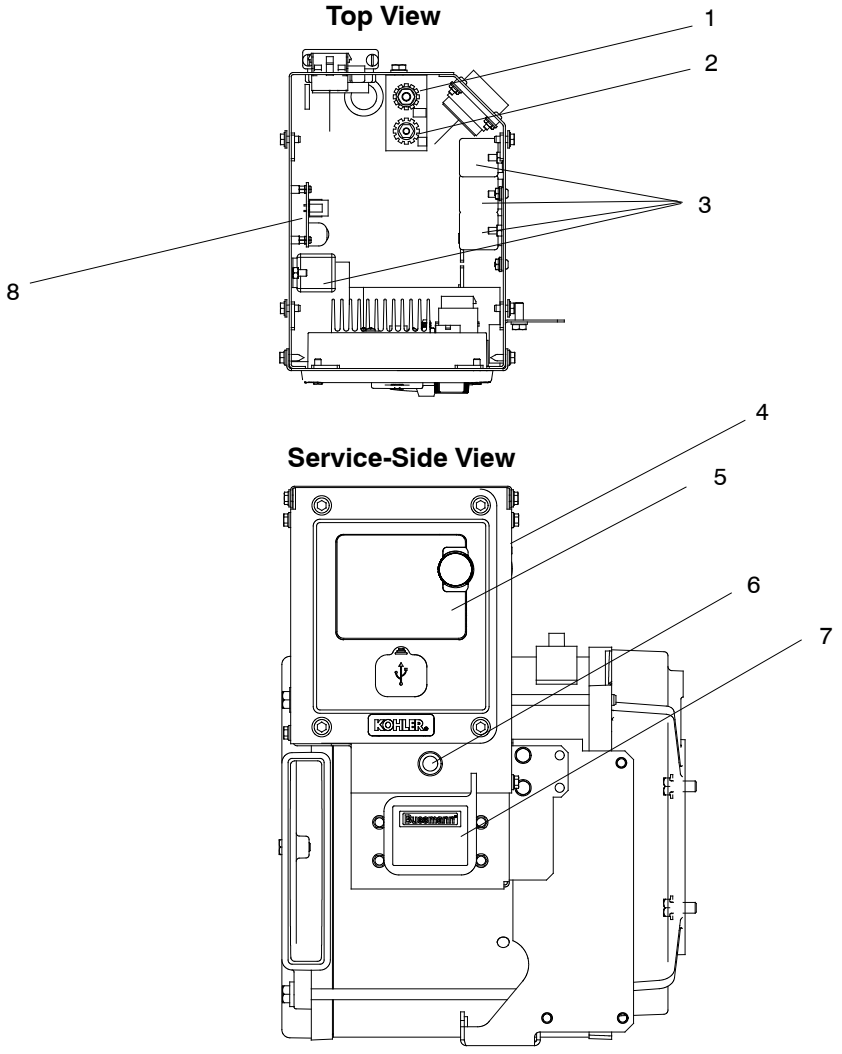
Notes

4.1 Introduction

This section describes the operation and replacement of the ADC II controller. Controller configuration and adjustment are explained in Section 4.7. See Section 3 for troubleshooting procedures.

See Figure 4-1 for the locations of the ADC II controller and related components.

A silicon controlled rectifier (SCR) module which is integral with the controller regulates the output voltage.



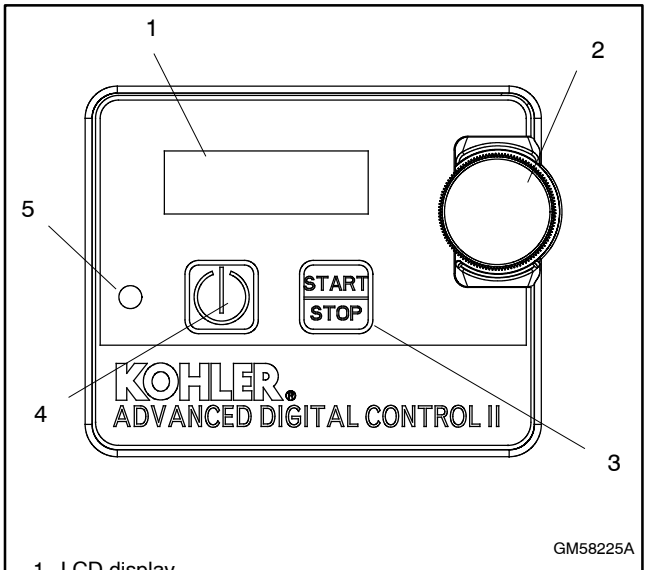
1. Ground stud
2. LO stud
3. Relays (P23, P24, P25, and P26)
4. Line circuit breaker panel
5. ADC II controller
6. F5 fuse location.
7. F1, F2, F3, and F4 fuse location.
8. CO sensor module

Figure 4-1 Advanced Digital Control (ADC II)

4.2 Advanced Digital Control II Operation

Figure 4-2 illustrates the user interface on the Advanced Digital Control II (ADC II).

Note: Have setup and adjustments of the Advanced Digital Control performed only by an authorized Kohler distributor/dealer.



1. LCD display
2. Control knob
3. Engine start/stop button
4. Power button
5. LED status indicator

Figure 4-2 Advanced Digital Control II

4.2.1 Controls and Indicators

LCD Display. The LCD display is backlit any time the generator set is running or for at least 30 seconds after a user manipulates a button or the control knob. The LCD displays generator status, run time hours, fault shutdowns, and fault warnings.

Control Knob. Rotate the control knob clockwise to increase a value or move down the menu structure. See Figure 4-3 for menu items.

Rotating the control knob to position:	Menu Item
1	Hourmeter/Status
2	Voltage and Frequency
3	Line 1 to neutral voltage and Line 2 to neutral voltage
4	Engine temperature (°F) Oil pressure (psi)
5	Battery voltage RPM
6	Next maintenance interval
7	Software version
8	ECM version
9	Contrast (lighting)
10	Event log
11	Fuel prime

Figure 4-3 Menu Items

Engine Start/Stop Button. The Engine Start/Stop button toggles the running state of the engine. When the controller is off, it has no effect. When the controller is in a low-power mode, the Engine Start/Stop button starts the engine.

Power Button. The Power button toggles the controller between on and off. When the controller if off, it does not respond to any input except the Power button.

LED Status Indicator. The LED provides a summary of the generator state:

- **Green** indicates no known problem
- **Red** indicates one or more faults (i.e. the generator cannot operate)
- **Amber** indicates no faults but one or more warnings (i.e. the generator can operate)
- **Slow** blink indicates that the generator is not running
- **Steady** indicates that the generator is running
- **Off** indicates that the unit is off

Figure 4-4 shows the possible LED displays.

LED Status Indicator	Power Button	Engine	Condition
Off	Off	Stopped	Any
Slow blink green	On	Stopped	No fault, No warning
Steady green	On	Running	No fault, No warning
Slow blink red	On	Stopped	Fault
Steady amber	On	Running	Warning
Slow blink amber	On	Stopped	Warning

Figure 4-4 Possible LED Status Indicator Displays

The controller is factory-set and should not require configuration or adjustment under normal operating conditions. If the generator set is reconnected to a different voltage and/or frequency, see Section 4.7 for system configuration and adjustment instructions.

4.2.2 Starting the Generator Set

The following procedures describe the actions required to start the generator set.

⚠ WARNING

Explosion.
Gasoline vapors can cause explosion and severe injury or death.

Before starting the generator set, operate the blower 4 minutes and check the engine compartment for gasoline vapors.

Step	Action
1	**Operate the blower.** Operate the blower 4 minutes and check the engine compartment for gasoline vapors. **NOTE:** Many boat manufacturers recommend continuous blower operation while the generator set is operating. Read the vessel's owner's manual for further information.
2	**Open the fuel shut-off valve.** Open the manual fuel shut-off valve, if equipped.
3	**Start the generator set.** Press the generator set start/stop button to start.

Note: Opening seacock. Before starting the generator set, open the seacock to allow cooling water passage. Failure to do so could damage the seawater pump impeller and cause serious engine overheating damage.

Note: Transfer switch. Check that the marine ship-to-shore transfer switch, if equipped, is in the ship position.

Note: Close seacock if water enters the exhaust system. If water enters the exhaust system, close the seacock and drain the water from the exhaust system at the silencer's drain plug before attempting to start the generator set. A water-filled exhaust hose and silencer may hinder generator starting and cause seawater entry into the engine cylinders through the exhaust valves. Water ingested into the engine may cause major engine damage that the Kohler Co. warranty does not cover. If excessive cranking is a chronic problem, have the unit, including the exhaust system, serviced by an authorized Kohler® distributor/dealer.

There is a delay of about 2 seconds before the controller attempts to start the engine. The controller display indicates the crank cycle 1 code, Cranking. The controller attempts to start the generator set three times (three crank cycles, 7 seconds crank and 15 seconds off). If the generator set does not start in three attempts, the system shuts down on an overcrank fault.

Local Starting.

1. Press the Power Button to turn the controller on. The LED Status Indicator appears green and begins flashing.

2. Press the Start/Stop Button to start the generator set. The Advanced Digital Control II attempts to start the generator set in three crank cycles (crank cycle time is pre-programmed).

When the engine comes up to speed, the low oil pressure switch contacts open.

Note: The controller circuit board prevents fault shutdowns during startup until the crank disconnect relay energizes.

The cyclic cranking cycle is programmed into the controller's application code and is not adjustable in the field.

The factory sets the cranking cycle for three cycles of 7 seconds on time and 15 seconds off time. If the cranking cycle seems shorter than the factory setting, check the engine starting battery.

Remote Starting.

A remote start/stop switch (connected to P21 connector, leads 3 and 4) or a remote digital gauge (connected to P21 connector, pins 1, 2, and 5 via CAN) can be connected to the customer interface connection. See the wiring diagram in Section 7.

Note: A remote start/stop switch (connected to P21 connector, leads 3 and 4) is not available when configured for SmartCraft™.

Press the Power Button to turn the controller on. Consult the instruction sheet supplied with the remote start/stop switch or remote digital gauge for starting instructions.

Note: The ADC II allows three 7-second crank cycle attempts before the overcrank shutdown occurs.

Remote communications require an active (powered-up) controller. Be advised that when the generator is not running, the Advanced Digital Control II enters a low-power state with an average current drain of approximately 100 uA.

The ADC II will power down (0 mA draw) after 48 hours of inactivity. Press the start switch/button (once for the remote start/stop switch or twice for the remote digital gauge) to “wake up” the ADC II and start the generator set.

4.2.3 Running Sequence

When the engine speed reaches 750 rpm, the crank relay deenergizes. When the output voltage on leads 11 and 44 reaches above 30 VAC, the flash relay deenergizes.

4.2.4 Stopping the Generator Set

The following procedures describe the actions required to stop the generator set.

Local Stopping.

1. Run the generator set at no load for at least 2 minutes to ensure adequate engine cooldown.
2. Press the Start/Stop button to stop the generator set. The engine stops.
3. Press the Power Button to turn the controller off.

Remote Stopping.

1. Run the generator set at no load for at least 2 minutes to ensure adequate engine cooldown.
2. The generator set stops when the remote start/stop switch or remote digital gauge contacts close momentarily.

Consult the instruction sheet supplied with the remote start/stop switch or remote digital gauge for stopping instructions.

Note: ADC II powers down after 48 hours of inactivity. If the generator has been started, the controller will power down 48 hours after the generator stops.

Note: A remote start/stop switch (connected to P21 connector, leads 3 and 4) is not available when configured for SmartCraft™.

4.2.5 Fault Shutdowns and Warnings

The generator set shuts down automatically under the fault conditions listed in Figure 4-5 and Figure 4-7 and the controller displays a fault code. The generator set cannot be restarted until the fault condition is corrected and the controller is reset. See Section 4.2.6 to reset the controller after a fault shutdown. The controller resets automatically after a battery voltage fault condition is corrected.

Shutdown switches on the generator set automatically reset when the problem is corrected. The high engine temperature switch automatically resets when the generator set cools. However, the fault does not clear until the controller is reset.

The controller displays warning text but the generator set does not shut down under the conditions shown in Figure 4-6 and Figure 4-8.

Fault Shutdowns						
Code and Description	**Sensing Mechanism**	**Active State**	**Inhibit Time**	**Delay Time**	**Default Setting**	**Check**
Over crank (fault) Overcrank shutdown occurs after 3 unsuccessful starting attempts. The crank cycle is set for three starting attempts of 7 seconds cranking and 15 seconds rest. The generator set shuts down on an overcrank fault if no engine rotation is sensed.	Fail to start	Excessive crank cycles	0 sec	7 sec on/ 15 sec off	3 crank cycles	Check the fuel supply and battery. Also check for loose connections. Check spark plug. Check for a locked rotor. Contact an authorized distributor/dealer for service if problem continues.
Locked rotor (fault) Overcrank (locked rotor) shutdown. A locked rotor condition indicates that there is no engine rotation when the starter is engaged. The controller indicates the fault after an engine speed of 0–5 rpm is detected for a max. of 3 seconds.	Fail to crank	Excessive locked rotor cycles	0 sec	3 sec	3 sec	Contact an authorized distributor/dealer for service if problem continues.
Low oil pres (fault) Low oil pressure shutdown occurs if a low oil pressure condition exists. **Note:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine. The controller displays a low oil pressure shutdown fault 35 seconds from engine start when the low oil pressure switch is activated (to below 7 psi). The controller inhibits the fault for at least 30 seconds after crank disconnect speed is reached. After the 30-second inhibit period, there is a 5-second delay after activation of the low oil pressure signal before the shutdown occurs.	ADC II data	Below setting/ grounded switch	30 sec	5 sec	7 psi	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low. Check the low oil pressure switch connections and operation. Check the oil pump and lubrication system.
Over speed (fault) Overspeed shutdown occurs if the engine speed exceeds the default setting.	ADC II data	Above setting	0 sec	1 sec	70 Hz	Check engine governing system controlled by the engine ECM. Contact an authorized distributor/dealer for service if problem continues.
Coolant loss (fault) Loss of coolant shutdown occurs after a loss of seawater pressure condition is detected.	Digital input	Grounded	30 sec	5 sec	N/A	Check for a clogged seawater intake or sea strainer. Check for a damaged seawater pump impeller. Check for a clogged or dirty seawater flow switch. Check for damaged water lines. Check for proper installation. Check for inlet restriction exceeding the seawater pump's maximum inlet restriction.
Hi eng temp (fault) High engine temperature shutdown occurs if the engine coolant temperature exceeds the default setting. **Note:** The high engine temp. shutdown functions only when the coolant level is in the operating range.	ADC II analog data	Above setting	30 sec	5 sec	230° F	Check for a low engine coolant level. Check seawater pump impeller, strainers, and seacock.

Fault Shutdowns						
Code and Description	**Sensing Mechanism**	**Active State**	**Inhibit Time**	**Delay Time**	**Default Setting**	**Check**
Aux input (fault) Auxiliary fault input shutdown. **Note:** Input from a customer-supplied switch that closes when the fault is active.	Digital input	Grounded	3 sec	0.3 sec	N/A	Check the cause of the auxiliary fault. Check the condition and operation of the customer-supplied equipment connected to the auxiliary fault input.
Hi CO: sensor (fault) Carbon monoxide presence detected from sensor. Sensor fault shutdown occurs because of the presence of CO.	Pulsed signal	20 Hz	0 sec	10 sec	N/A	**Immediate service required**. Contact an authorized distributor/dealer for service. Ensure windows are open for proper ventilation. Operate the blower to expel dangerous fumes. Move the vessel away from other vessels (as another vessel may be the source for the presence of the CO). Check the generator exhaust system (see the O/M).
Hi CO: engine (fault) Carbon monoxide shutdown fault detected from ADC II. Shutdown occurs because of the presence of CO or deteriorating emission-control components (such as the catalyst).	ADC II data	Control limit	0 sec	15 sec	N/A	**Immediate service required**. Contact an authorized distributor/dealer for service. Ensure windows are open for proper ventilation. Operate the blower to expel dangerous fumes. Move the vessel away from other vessels (as another vessel may be the source for the presence of the CO). Check the generator exhaust system (see the O/M).
No CO sensor (fault) Carbon monoxide sensor missing. Shutdown occurs if communication is lost between the CO sensor and the ADC.	Pulsed signal	No signal	0 sec	10 sec	N/A	Check the connections to the CO sensor. If connections are okay, replace the CO sensor. Contact an authorized distributor/dealer for service.
Over voltage (fault) Overvoltage shutdown occurs if the voltage exceeds the default setting of the voltage regulator setpoint.	Alternator output	Above setting	10 sec	2 sec	120% of nominal	Check AC voltage. Check wiring and connections. Contact an authorized distributor/dealer for service if problem continues.
Under volt (fault) Undervoltage shutdown occurs if the voltage falls below the default setting of the voltage regulator setpoint.	Alternator output	Below setting	10 sec	10 sec	80% of nominal	Reduce the load and restart the generator set. Check wiring and connections. Check AC voltage and adjust, if necessary. Separately excite unit. Check stator continuity. Check the F5 fuse. Contact an authorized distributor/dealer for service if problem continues.
Over freq (fault) Overfrequency shutdown occurs when the governed frequency exceeds the default setting of the system's frequency setpoint.	Alternator output	Above setting	10 sec	5 sec	110% of nominal	Check engine governing system controlled by the engine ECM. Contact an authorized distributor/dealer for service if problem continues.

Fault Shutdowns						
Code and Description	**Sensing Mechanism**	**Active State**	**Inhibit Time**	**Delay Time**	**Default Setting**	**Check**
Under freq (fault) Underfrequency shutdown occurs when the governed frequency falls below the default setting of the system's frequency setpoint .	Alternator output	Below setting	10 sec	5 sec	90% of nominal	Reduce the load and restart the generator set. Check P2 AC sensing connection at the controller. Contact an authorized distributor/dealer for service if problem continues.
HVR Comm Err (fault) Hybrid Voltage Regulator (HVR) Communications Loss/Remote CAN communication loss shutdown. Communications loss between the voltage regulator and controller circuits.	CAN	Loss of communication	0 sec	10 sec	N/A	Check the remote digital gauge and connection. Replace the controller.

Figure 4-5 Advanced Digital Control II Fault Shutdown

Warnings						
Code and Description	**Sensing Mechanism**	**Active State**	**Inhibit Time**	**Delay Time**	**Default Setting**	**Check**
High battery High battery voltage warning. This fault condition does not inhibit engine starting. The fault condition clears when the battery voltage returns to a voltage within the limits.	Analog input	Above setting	0 sec	10 sec	16 volts for 12 volt system	Check the battery rating and condition.
Low battery Low battery voltage warning. This fault condition does not inhibit engine starting. The fault condition clears when the battery voltage returns to a voltage within the limits.	Analog input	Below setting	0 sec	90 sec	**Standby Mode:** 11 volts for 12 volt system **Run Mode:** 12.6 volts for 12 volt system	Check the battery rating and condition. Charge or replace the battery.
Weak battery Low cranking battery	Analog input	Below setting	0 sec	2 sec during cranking	9 VDC	Check the battery rating and condition. Charge or replace the battery.
Hi CO: engine High CO from ADC II. Fault code is displayed if the presence of CO is detected because of the time-weighted average presence of CO. Activates the CO cabin alarms.	ADC II data	Control limit	0 sec	5 sec	N/A	Ensure windows are open for proper ventilation. Operate the blower to expel dangerous fumes. Move the vessel away from other vessels (as another vessel may be the source for the presence of the CO). Check the generator exhaust system (see the O/M). Contact an authorized distributor/dealer for service.
Hi CO: sensor High CO from sensor. Fault code is displayed if the presence of CO is detected. Warning occurs if the sensor detects acceptable but increasing CO levels.	Pulsed signal	10 Hz	0 sec	10 sec	N/A	Ensure windows are open for proper ventilation. Operate the blower to expel dangerous fumes. Move the vessel away from other vessels (as another vessel may be the source for the presence of the CO). Check the generator exhaust system (see the O/M). Generator service for emissions required. Contact an authorized distributor/dealer for service.
CO sensr err Faulty CO sensor. Fault code is displayed if the CO sensor is inoperative.	Pulsed signal	5 Hz	0 sec	10 sec	N/A	Replace the CO sensor. Contact an authorized distributor/dealer for service.

Warnings						
Code and Description	**Sensing Mechanism**	**Active State**	**Inhibit Time**	**Delay Time**	**Default Setting**	**Check**
Low oil pres Low oil pressure. With the sender kit installed, the controller displays a low oil pressure warning 30 seconds from engine start when the engine oil pressure is less than 17 psi. The controller inhibits the warning for at least 30 seconds after crank disconnect speed is reached. After the 30-second inhibit period, there is no delay after going below 17 psi before the low oil pressure warning is indicated.	Analog	Pressure below setpoint	30 sec	0 sec	17 psi	Check for leaks in the lubrication system. Check the oil level and add oil if the level is low.
Hi eng temp High engine coolant temperature. The controller displays a high engine temperature warning 30 seconds from engine start when the engine temperature is greater than 210° F. The controller inhibits the warning for at least 30 seconds after crank disconnect speed is reached. After the 30-second inhibit period, there is no delay after reaching 210° F before the warning is indicated.	ADC II data	Above setting	30 sec	0 sec	210° F	Check for a low engine coolant level. Check seawater system for reduced flow. NOTE: Allow the generator set to cool down before checking.
Maint req Maintenance required	Clock	N/A	0 sec	0 sec	N/A	

Figure 4-6 Advanced Digital Control II Warnings

In addition to the fault shutdowns and warnings included in Figure 4-5 and Figure 4-6, other fault shutdowns and warnings may occur (see Figure 4-7 and Figure 4-8).

Fault Shutdowns:		
Text Displayed	**Description**	**Check**
Check engine †	Check engine	A check engine fault occurs when the ECM sends a signal for the generator set controller to shut down because the engine has stalled. An engine stall could be related to the loss of fuel or other engine peripheral. Check the following: Fuel supply High fuel restrictions Air leak in the supply side of the fuel system Inoperative low or high pressure fuel pump Fuel vaporization in higher than maximum temperature operation specifications.
ECM voltage ‡	No or low voltage to the ECM	Check if the 10 amp, F1 fuse is blown or missing. Check if lead 70 circuit is open between plug, P1-4 and the battery during cranking attempts. Check for low voltage on lead 70. Low voltage could be caused by the following: Poor connection at the 10P1 lead at the battery Poor connection at the incoming side of the F1 fuse Damaged F1 fuse holder or fuse Poor connection at the outgoing side of the F1 fuse High contact resistance across plug. P24 An inoperative P25 relay coil An inoperative component connected to the customer connection plug, P21-7
TPS input hi	Throttle Position Sensor Input High	The TPS Range High and TPS Input High conditions are closely related. If the input reaches 5 VDC, the TPS Input High condition is indicated. The range error is dynamically determined and may or may not occur before reaching 5 VDC. In some cases, both may occur simultaneously. The ADC II protective monitor will react to only one shutdown condition, therefore whichever of these faults is detected first will be indicated as the reason for the shutdown. A TPS Input High condition exists when the closed loop feedback does not correspond with what the ADC II is expecting. The threshold for the TPS Input High is a signal voltage of 4.8 volts or greater. The controller indicates the fault within 1 second of the condition being present. Fault appears if the sensor signal wire is shorted or the sensor has failed. Check the throttle connector and sensor wiring for a shorted circuit: ETC pin 6 to ADC II pin 9 (217) ETC pin 2 to ADC II pin 28 (SG)
TPS range hi	Throttle Position Sensor Range High	The TPS Range High and TPS Input High conditions are closely related. If the input reaches 5 VDC, the TPS Input High condition is indicated. The range error is dynamically determined and may or may not occur before reaching 5 VDC. In some cases, both may occur simultaneously. The ADC II protective monitor will react to only one shutdown condition, therefore whichever of these faults is detected first will be indicated as the reason for the shutdown. Fault appears if the sensor potentiometer has malfunctioned. Check for dirt or oxidation on the sensor traces. Check the throttle connector and pins for corrosion. To check, disconnect the throttle connector and measure the resistance of 1.25 kOhms ±30% from: TPS pin 2 (GND) to pin 6 (TPSI SIGNAL) TPS pin 3 (PWR) to pin 6 (TPSI SIGNAL) Note: Do not service this sensor. Repair by replacing the throttle body assembly.
† **Note**: Available on software version 1.3.0 or higher. On software version 1.2.0 and below, this condition was displayed as Out of fuel.		
‡ **Note:** Available on software version 1.3.0 or higher. On software version 1.2.0 and below, this condition was displayed as Low battery fault.		

Fault Shutdowns:		
Text Displayed	**Description**	**Check**
TPS range lo	Throttle Position Sensor Range Low	The TPS Range Low and TPS Input Low conditions are closely related. If the input reaches 0 VDC, the TPS Input Low condition is indicated. The range error is dynamically determined and may or may not occur before reaching 0 VDC. In some cases, both may occur simultaneously. The ADC II protective monitor will react to only one shutdown condition, therefore whichever of these faults is detected first will be indicated as the reason for the shutdown. Fault appears if the sensor potentiometer has malfunctioned. Check for dirt or oxidation on the sensor traces. Check the throttle connector and pins for corrosion. To check, disconnect the throttle connector and measure the resistance of 1.25 kOhms ±30% from: TPS pin 2 (GND) to pin 6 (TPS1 SIGNAL) TPS pin 3 (PWR) to pin 6 (TPSI SIGNAL) Note: Do not service this sensor. Repair by replacing the throttle body assembly.
TPS input lo	Throttle Position Sensor Input Low	The TPS Range Low and TPS Input Low conditions are closely related. If the input reaches 0 VDC, the TPS Input Low condition is indicated. The range error is dynamically determined and may or may not occur before reaching 0 VDC. In some cases, both may occur simultaneously. The ADC II protective monitor will react to only one shutdown condition, therefore whichever of these faults is detected first will be indicated as the reason for the shutdown. A TPS Input Low condition exists when the closed loop feedback does not correspond with what the ADC II is expecting. The threshold for the TPS Input Low is a signal voltage of 0.7 volts or lower. The controller indicates a fault within 1 second of the condition being present. Fault appears if the sensor signal wire is disconnected or the circuit is opened to the ADC II (TPS range lo and TPS input lo are expected faults when the ETC connector is unplugged). Check the throttle connector connection and sensor for an open circuit: ETC pin 6 to ADC II pin 9 (217) ETC pin 2 to ADC II pin 28 (SG)
ETC sticking	Electronic Throttle Control Sticking	Fault appears if either of the electronic throttle control driver signals are opened or disconnected. This happens if the throttle plate sticks inside the throttle body. Check for debris or obstructions inside the throttle body; a loose throttle plate, or the throttle-plate shaft for bearing wear. Check the ETC driver wiring for an open circuit: ETC+ pin1 to ADC II pin 30 ETC- pin 4 to ADC II pin 31 Check the ETC internal motor drive by disconnecting the throttle connector and measuring the motor drive resistance at the throttle: TPS pin 1 (+DRIVER) to pin 4 (-DRIVER) approx. 3.0 Ohms ±30%. Note: Do not service the throttle components. Repair or replace the throttle body assembly.
ETC driver	Electronic Throttle Control (ETC) Driver Fault	Fault appears if an overcurrent condition occurs on either the ETC+ or ETC- driver signals. Check the ETC driver wiring for a shorted circuit: ETC+ pin 1 to ADC II pin 30 ETC- pin 4 to ADC II pin 31 Check the ETC internal motor drive by disconnecting the throttle connector and measuring the motor drive resistance at the throttle: TPS pin 1 (+DRIVER) to pin 4 (-DRIVER) approx. 3.0 Ohms ±30%.
MAP input hi	Manifold Air Pressure (MAP) Sensor Input High	The controller indicates a MAP Input High/Low fault within 1 second of the condition being present. The manifold air pressure sensor fault appears if the TMAP pressure signal wire is shorted to power, shorted to the IAT signal, the TMAP has failed, or the ADC II has failed. Check the TMAP connector and MAP signal wiring for a shorted circuit: TMAP pin 4 to ADC II pin 20 (200) TMAP pin 1 to ADC II pin 28 (XDRG transducer GND) TMAP pin 3 to ADC II pin 27 (OPS transducer GND) Check the MAP sensor by disconnecting the TMAP connector and measuring at the sensor: TMAP pin 1 (GND) to pin 4 (PRESSURE SIGNAL KPA) of 2.4 - 8.2 kOhms TMAP pin 3 (PWR) to pin 4 (PRESSURE SIGNAL KPA) of 3.4-8.2 kOhms

Fault Shutdowns:		
Text Displayed	**Description**	**Check**
MAP input lo	Manifold Air Pressure (MAP) Sensor Input Low	The controller indicates a MAP Input High/Low fault within 1 second of the condition being present. The manifold air pressure sensor fault appears if the TMAP pressure signal wire is disconnected or the circuit is opened to the ADC II. (MAP input lo and IAT input hi are expected faults when the TMAP connector is unplugged.) Check the TMAP connector and MAP signal wiring for an open circuit: TMAP pin 4 to ADC II pin 20 (200) TMAP pin 1 to ADC II pin 28 (XDRG transducer GND) TMAP pin 3 to ADC II pin 27 (OPS transducer GND) Check the MAP sensor by disconnecting the TMAP connector and measuring at the sensor: TMAP pin 1 (GND) to pin 4 (PRESSURE SIGNAL KPA) of 2.4 – 8.2 kOhms TMAP pin 3 (PWR) to pin 4 (PRESSURE SIGNAL KPA) of 3.4–8.2 kOhms
Trans hi	Transducer voltage (XDRP) Sensor Input High	Fault appears if the sensor power from the ADC II increases above 5.9 VDC. Measure the transducer power at the TMAP connector with a multimeter: TMAP pin 3 +5VDC to TMAP pin 1 XDCR GND Verify transducer power at the ADC II with a multimeter: ADC II pin 29 +5VDC to ADC II pin 28 XDCR GND Verify transducer power at ETC with a multimeter: ETC pin 3 XDCR PWR to ETC pin 2 XDCR GND
Trans lo	Transducer voltage (XDRP) Sensor Input Low	Fault appears if the sensor power from the ADC II drops below 4.8 VDC. (TPS range lo, TPS input lo, and MAP input lo are expected faults when the transducer power is lost). Measure the transducer power at the TMAP connector with a multimeter: TMAP pin 3 +5VDC to TMAP pin 1 XDCR GND Verify transducer power at the ADC II with a multimeter: ADC II pin 29 +5VDC to ADC II pin 28 XDCR GND Verify transducer power at ETC with a multimeter: ETC pin 3 XDCR PWR to ETC pin 2 XDCR GND
IAT input hi	Intake Air Temperature (IAT) Input Sensor High	The controller indicates an IAT Input High/Low fault within 1 second of the condition being present. Fault appears if the TMAP temperature signal wire is disconnected or the circuit is open to the ADC II. Check the TMAP connector and IAT signal wiring for an open circuit: TMAP pin 2 to ADC II pin 21 (SIGNAL) TMAP pin 1 to ADC II pin 28 (GND) transducer ground TMAP pin 3 to ADC II pin 27 (OPS transducer ground) To check the IAT sensor of the TMAP, disconnect the TMAP connector and measure the IAT resistance. See Figure 5-14.
IAT input lo	Intake Air Temperature (IAT) Input Sensor Low	The controller indicates an IAT Input High/Low fault within 1 second of the condition being present. Fault appears if the TMAP temperature signal wire has become shorted to ground, shorted to the MAP signal, the TMAP has failed or the ADC II has failed. Check the TMAP connector and IAT signal wiring for an open circuit: TMAP pin 2 to ADC II pin 21 (SIGNAL) TMAP pin 1 to ADC II pin 28 (GND) transducer ground TMAP pin 3 to ADC II pin 27 (OPS transducer ground) To check the IAT sensor of the TMAP, disconnect the TMAP connector and measure the IAT resistance. See Figure 5-14.
ECT input hi	Engine Coolant Temperature (ECT) Sensor Input High	The controller indicates an ECT Input High fault within 1 second of the condition being present and an ECT Input Low warning within 1 second of the condition being present. Fault appears if the coolant sensor wire is disconnected or the circuit is opened to the ADC II. Check if the sensor connector is disconnected or for an open circuit: ADC II pin 11 to ECT pin A ADC II pin 28 to ECT pin B

Fault Shutdowns:		
Text Displayed	**Description**	**Check**
O2 input hi	Oxygen Sensor Input High	The controller indicates an O2 Input High/Low fault within 1 second of the condition being present. Fault appears if the O2 sensor ADC II driver signal is shorted to power. Check if the O2 sensor is shorted to +5VDC or battery: O2 (SIGNAL) pin B to ADC II pin 22 Verify operation of O2 sensor heater circuit by measuring circuit resistance of 2.1 ohms ±0.4 ohms: O2 pin C (HEATER GND) to pin D (HEATER PWR)
O2 input lo	Oxygen Sensor Input Low	The controller indicates an O2 Input High/Low fault within 1 second of the condition being present. Fault appears if the oxygen sensor input is low. Check the O2 sensor connector and wiring for a short to ground: ADC II pin 22 to O2 sensor pin B ADC II pin 28 to O2 sensor pin A
O2 adapt	O2 Adapt Limit Fault	Fault appears when the O2 sensor can no longer switch or be driven above or below 500mv by the ADC II. O2 sensor is not switching across the reference AFR voltage. Check for an open coil by disconnecting the connector and measuring the resistance (approx. 26 ohms ±2 ohms): Pin A (SIGNAL) to pin B (PWR)
CAN loss	CAN Receive Message Fault	Replace the controller.
Overload	Power Limit Shutdown	An overload condition exists when the controller senses the generator is overloaded. If sensed, the controller will display an overload warning for 30 seconds and if no action is taken to reduce the load during these 30 seconds, the unit will shutdown on an overload fault. Action to take: Reduce the electrical load. Review the troubleshooting chart in Section 3.
Injector	Injector Fault	Fault appears when the power to the injector is low or missing. Check injector connection.
Out of fuel *	Loss of fuel	An out of fuel condition exists when the generator set shuts down for an unknown reason contributed to no or lack of fuel.
* **Note**: Available on software version 1.2.0 or below. On software version 1.3.0 and higher, this condition is displayed as Check engine.		

Figure 4-7 Fault Shutdowns

Fault Warnings:		
Text Displayed	**Description**	**Check**
EST 1 Low	Electronic Spark 1 Timing Low	An EST failure condition exists when the spark signal is pulled high or low. The controller indicates EST1 fault within 1 second of the condition being present. The Electronic Spark Timing (EST) is a current driver signal. This fault appears if the signal from the ADC II is shorted to ground or the coil driver signal is low or undercurrent. Check the coil driver wiring and connectors for shorts: ADC II pin 17 to COIL pin A Verify GND on COIL pin B Verify GND on COIL pin C Verify GND on COIL pin D Verify +12VDC on COIL pin E To check the internal circuit, disconnect the coil connector and measure the resistance from pin to pin. See Figure 5-19.
EST 1 High	Electronic Spark 1 Timing High	An EST failure condition exists when the spark signal is pulled high or low. The controller indicates EST1 fault within 1 second of the condition being present. To Electronic Spark Timing (EST) is a current driver signal. This fault appears if the signal from the ADC II is open or lost or the coil driver signal is high or overcurrent. Check the coil driver wiring for an open circuit or disconnected connector: ADC II pin 17 to COIL pin A Verify GND on COIL pin B Verify GND on COIL pin C Verify GND on COIL pin D Verify +12VDC on COIL pin E To check the internal circuit, disconnect the coil connector and measure the resistance from pin to pin. See Figure 5-19.
EST 2 Low	Electronic Spark 2 Timing Low	An EST failure condition exists when the spark signal is pulled high or low. The controller indicates EST2 fault within 1 second of the condition being present. The Electronic Spark Timing (EST) is a current driver signal and this fault appears if the signal from the ADC II is shorted to ground or the coil driver signal is low or undercurrent. Check the coil driver wiring and connector for shorts: ADC II pin 18 to COIL pin A Verify GND on COIL pin B Verify GND on COIL pin C Verify GND on COIL pin D Verify +12VDC on COIL pin E To check the internal circuit, disconnect the coil connector and measure the resistance from pin to pin. See Figure 5-19.
EST 2 High	Electronic Spark 2 Timing High	An EST failure condition exists when the spark signal is pulled high or low. The controller indicates EST2 fault within 1 second of the condition being present. The Electronic Spark Timing (EST) is a current driver signal and this fault appears if the signal from the ADC II is open or lost or the coil driver signal is high or overcurrent. Check the coil driver wiring for an open circuit or disconnected connector: ADC II pin 18 to COIL pin A Verify GND on COIL pin B Verify GND on COIL pin C Verify GND on COIL pin D Verify +12VDC on COIL pin E To check the internal circuit, disconnect the coil connector and measure the resistance from pin to pin. See Figure 5-19.

Fault Warnings:		
Text Displayed	**Description**	**Check**
Oil sens err	Oil Pressure Sensor. Available only when sender kit is installed.	The oil pressure input high warning can only be detected when the controller is configured to monitor an oil sending unit. The controller indicates the warning after the input is set to a 5.0 volt signal for 0.3 seconds. The oil pressure input low warning can only be detected when the controller is configured to monitor an oil sending unit. The controller indicates the warning after the sender generates a 0.0 volt signal for 0.3 seconds.
ETC spring	Electronic Throttle Control (ETC) Spring Test Failed	Upon initial engine startup, the ADC II performs a safety test of the throttle return spring. If this spring has become weak, the throttle will fail this test and set the fault. Perform a throttle spring test by cycling the ignition and rechecking the fault. Note: Do not service the throttle components. Repair or replace the throttle body assembly.
ECT input lo	Engine Coolant Temperature (ECT) Sensor Input Low	The controller indicates an ECT Input High fault within 1 second of the condition being present and an ECT Input Low warning within 1 second of the condition being present. Fault appears if the coolant sensor wire is shorted to ground or the sensor has failed. Check the sensor connector and wiring for a short to GND: ADC II pin 11 to ECT pin A ADC II pin 28 to ECT pin B
O2 sens open	Oxygen (O2) Sensor Open Circuit	The warning is displayed when the controller senses an open circuit. Troubleshoot the P2 oxygen sensor connections.
O2 limit err	O2 Limit Error	Oxygen sensor voltage limits exceeded. Replace the oxygen sensor.
Starter	Starter Fault	The starter does not engage. Troubleshoot the starter circuit and starter motor.
Overload	Power Limit Warning	An overload condition exists when the controller senses the generator is overloaded. If sensed, the controller will display an overload warning for 30 seconds and if no action is taken to reduce the load during these 30 seconds, the unit will shutdown on an overload fault. Action to take: Reduce the electrical load. Review the troubleshooting chart in Section 3.

Figure 4-8 Fault Warnings

4.2.6 Resetting the Controller after a Fault Shutdown

Note: A fault is identified by a red blinking light in the LED status indicator.

Always identify and correct the cause of a fault shutdown before resetting the controller. Use the following procedure to reset the generator set controller after a fault shutdown.

1. Disconnect the generator set engine starting battery(ies), negative (–) lead first.
2. Disconnect the generator set from the load. See the safety precautions at the beginning of this manual before proceeding.
3. Identify and correct the cause of the fault shutdown. See the safety precautions at the beginning of this manual before proceeding. Refer to Section 3, Troubleshooting.
4. Reconnect the generator set to the load.
5. Reconnect the generator set engine starting battery, negative (–) lead last.
6. Push the Advanced Digital Control knob.
7. Rotate the control knob to CONFIRM CLR FAULT: YES
8. Push the control knob.
9. Start the generator set by pressing the generator set start/stop button to START. Test operate the generator set to verify that the cause of the shutdown has been corrected.
10. Shut the generator off by pressing the generator set start/stop to the STOP position.

4.2.7 USB Connection

The Advanced Digital Control II includes a USB connection for updating software and configuring parameters. See Figure 1-2 for location.

Note: Have software downloads, setup, and adjustments of the Advanced Digital Control performed only by an authorized Kohler distributor/dealer.

Click on the **TechTools** button to find the following topics:

- **Software** used by generator set controllers including updates and documentation references.
- **Network Communications** provides basics to terms, protocols, standards, wiring, configurations, and model.
- **Engine Electronic Control Module (ECM)** has information about electronic devices provided by the engine manufacturer to manage engine data.

4.3 Circuit Protection

If the generator set circuit breaker trips or the fuses blow repeatedly, see Section 3 for possible causes.

4.3.1 Line Circuit Breaker

A line circuit breaker interrupts the generator output in the event of a fault in the wiring between the generator and the load. The line circuit breaker location is shown in Figure 1-2. If the circuit breaker trips, reduce the load and switch the breaker back to the ON position.

4.3.2 Fuses

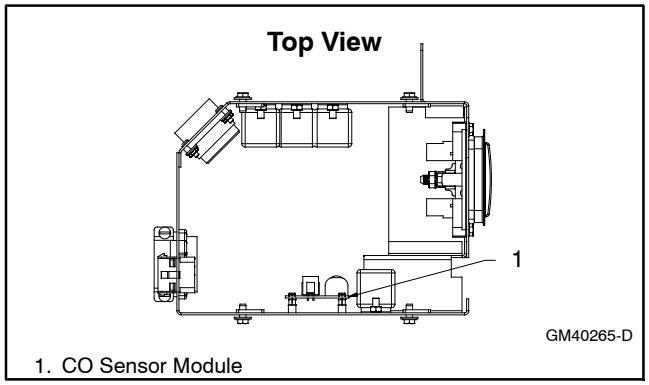
The junction box contains five fuses. See Figure 1-2 for the fuse locations. Always identify and correct the cause of a blown fuse before restarting the generator set. Refer to Section 4 for conditions that may indicate a blown fuse. Obtain service from an authorized distributor/dealer.

Schematic Diagram Fuse Reference Number	Location	Fuse	Amps
F1	Fuse block, position 1	Customer connection	10
F2	Fuse block, position 4	Voltage regulator	25
F3	Fuse block, position 5	Injector, CO sensor, fuel pumps, oxygen sensor, and coils	20
F4	Fuse block, position 8	Controller	10
F5	Fuse holder	Auxiliary winding	10

Figure 4-9 Fuses

4.4 CO Sensor Module

The CO sensor module is located behind the ADC II inside the junction box. Replace the CO sensor module every two years. See Figure 4-10 and Figure 4-11.



1. CO Sensor Module

Figure 4-10 CO Sensor Module Location

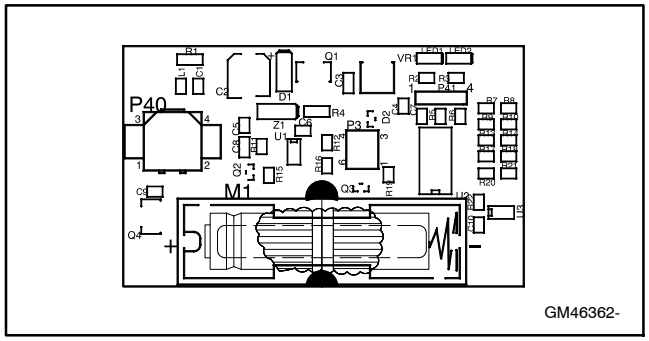
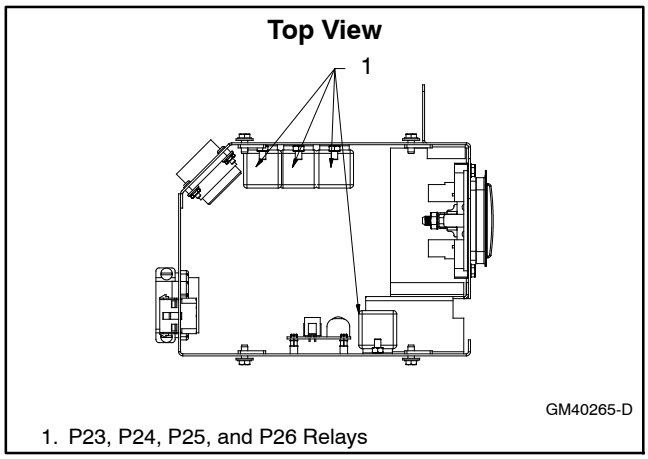


Figure 4-11 CO Sensor Module

4.5 Relays

The junction box contains four relays. See Figure 4-12, Figure 4-13 and Figure 4-14 for location and description.

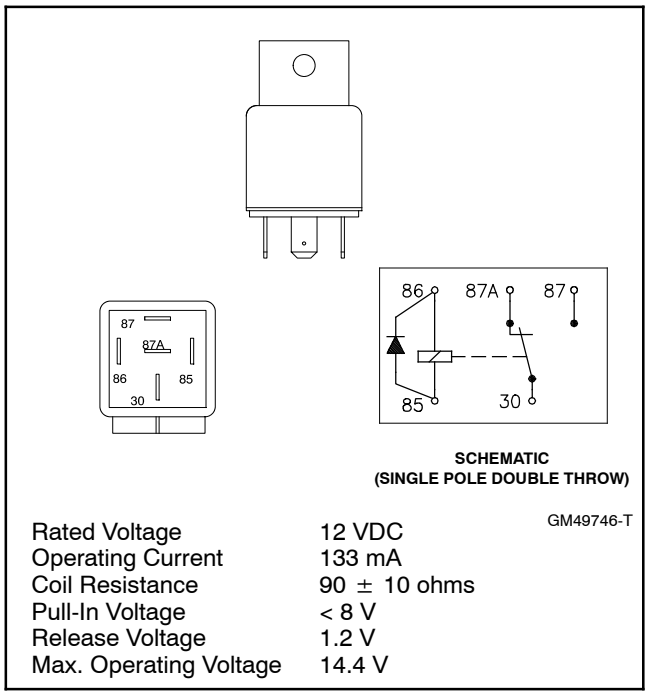


1. P23, P24, P25, and P26 Relays

Figure 4-12 Relay Location

Label	Relay
P23	Starter solenoid
P24	Main power relay
P25	Injector, CO Sensor, Fuel Pumps, Oxygen Sensor, and Coils
P26	Seawater flow switch

Figure 4-13 Relays



Rated Voltage	12 VDC
Operating Current	133 mA
Coil Resistance	90 ± 10 ohms
Pull-In Voltage	< 8 V
Release Voltage	1.2 V
Max. Operating Voltage	14.4 V

Figure 4-14 Relay Spec

4.6 Controller Replacement

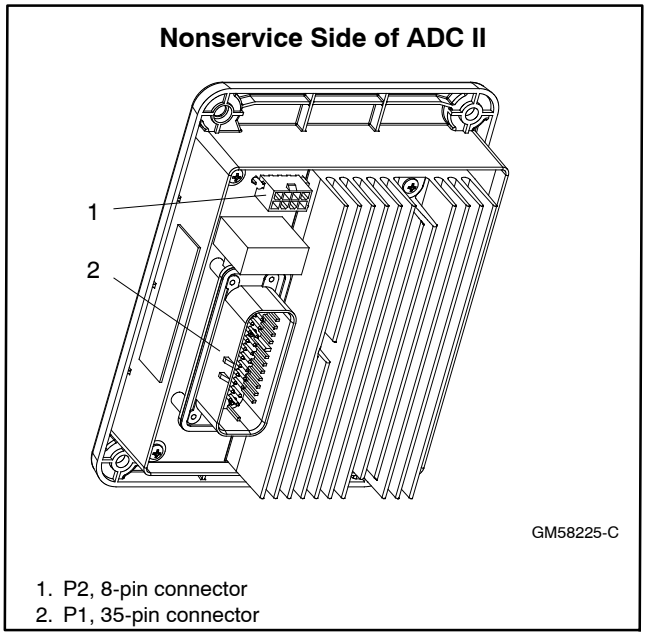
If the troubleshooting procedures in Section 3 identify a bad controller, use the procedure in this section for controller replacement. Always check the controller configuration, fuse, wiring, and connections before replacing the controller.

After replacing the controller, verify that the new controller's configuration settings match the generator set system voltage and frequency, unit configuration, engine data input types, battery voltage, and communications settings. Refer to Section 4.7 for instructions to check the controller configuration and to change the settings, if necessary.

After the controller configuration has been checked and set to match the generator set, use a voltmeter to check the generator set output voltage. If the output voltage needs adjustment, use the Voltage Adjustment Procedure in Section 4.7.

ADC II Controller Replacement Procedure

1. Push the generator set power button OFF.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (–) lead first.
4. Remove four mounting screws from the front of the controller.
5. Carefully pull the controller forward.
6. Disconnect plugs P1 and P2. See Figure 4-15.
7. Attach plugs P1 and P2 to the new controller.
8. Place the new controller into position and install the four mounting screws.
9. Reconnect the engine starting battery, negative (–) lead last.
10. Reconnect power to the battery charger, if equipped.
11. Follow the instructions in Section 4.7 to change the new controller's configuration settings to match the generator set system voltage and frequency, unit configuration, engine data input types, battery voltage, and communications settings.
12. Use a voltmeter to check the output voltage. Follow the instructions in Section 4.7 to adjust the output voltage and stability.



1. P2, 8-pin connector
2. P1, 35-pin connector

Figure 4-15 Controller Connections

4.7 Controller Configuration and Adjustment

This section contains instructions for using the controller's menus to check and adjust the generator output and controller configuration. The controller configuration and generator set output are factory-set and should not require field adjustment under normal circumstances. Check and adjust the configuration and/or output in the following cases:

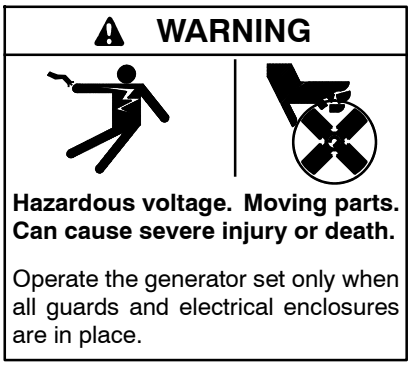
- Check and adjust the controller configuration and generator output after generator set reconnection to a different voltage.
- Check the controller configuration when troubleshooting generator set problems.
- Check and adjust the generator set output after installation if the voltage requires adjustment for a particular application.

4.7.1 Adjusting the Voltage, Gain, and Volts/Hz

After setting the system voltage, check the output voltage and adjust, if necessary, using the following procedures. Follow the instructions in Figure 4-18 to adjust the voltage, gain, and volts/Hz while the engine is running. Rotate the control knob clockwise to increase a setting or counterclockwise to decrease the setting.

Note: A digital multimeter that measures voltage and frequency is required for these adjustments.

4.7.2 Voltage Adjustment



Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Voltage Adjustment Procedure

1. With the generator set off, connect a digital voltmeter to the output leads or an electrical outlet on the load side of the generator set. Set the meter to measure voltage.
2. Start the generator set by pressing the Start/Stop Button.
3. Use the Advanced Digital Control II to adjust the voltage until the output voltage reaches the desired value.
4. Adjust the voltage stability (gain) to minimize light flicker. One rotation of the control knob is ±1 volt.
5. Readjust the voltage, if necessary.

Volts per Hertz (Hz) Adjustments

The cut-in frequency is preset for 58 Hz (60 Hz system) or 48 Hz (50 Hz system). When the frequency falls below the cut-in, output voltage is reduced to relieve the engine. The amount of the voltage reduced is set by the V/Hz slope adjustment. Monitor engine speed and output voltage as loads are applied.

- If there is excessive droop in engine speed and little droop in voltage, increase the V/Hz slope.
- If there is little engine speed droop but excessive voltage droop, decrease the V/Hz slope.

One rotation of the control knob is ±1 Hz.

1. Readjust the voltage stability (gain), if necessary.
2. Readjust the voltage, if necessary.
3. Stop the generator set.

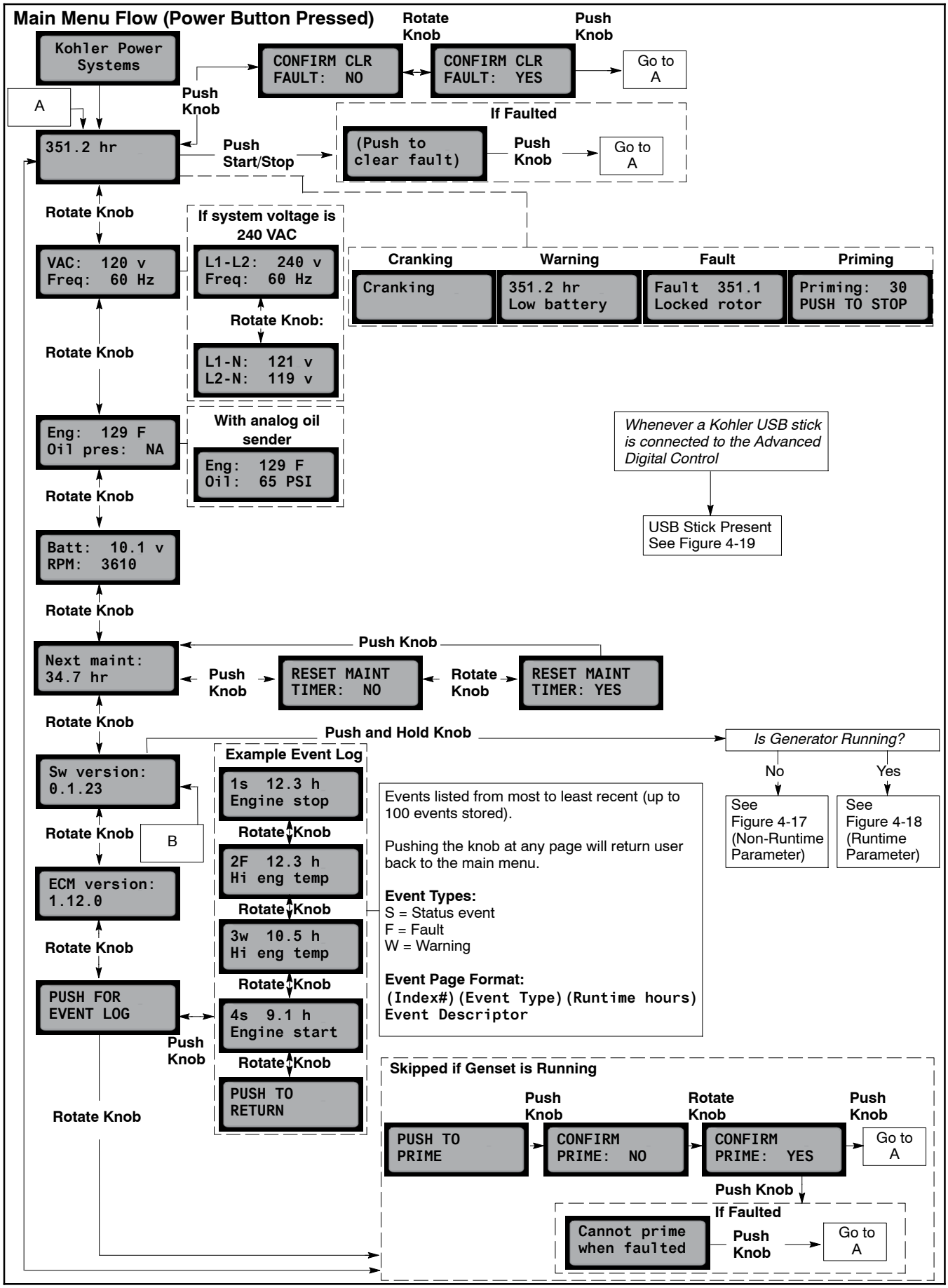


Figure 4-16 Advanced Digital Control, Main Menu Flow (5/7.5/10EKD and 4/6/8EFKD Models)

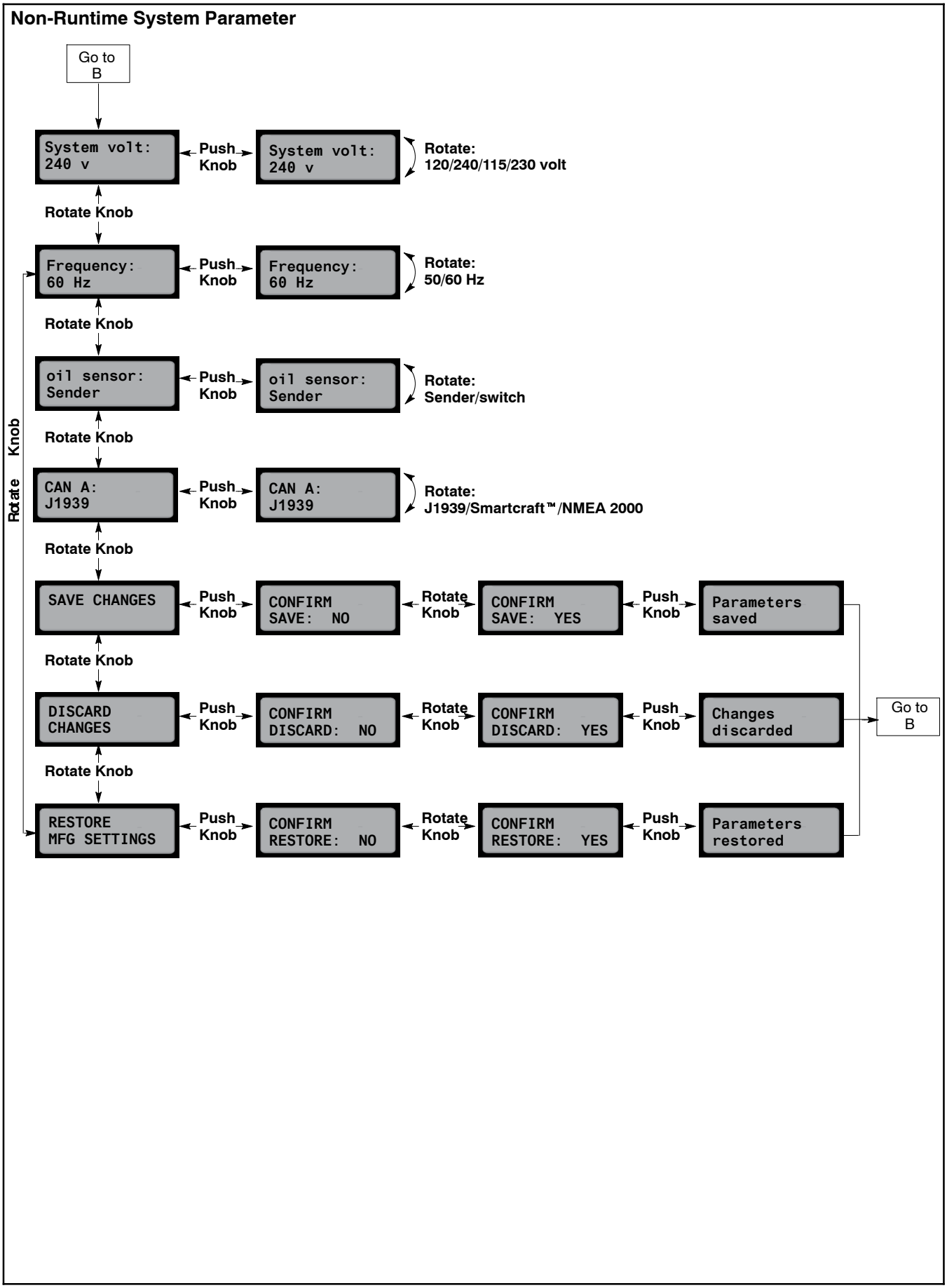


Figure 4-17 Advanced Digital Control, Non-Runtime System Parameter (5/7.5/10EKD and 4/6/8EFKD Models)

Runtime Adjustment Parameter

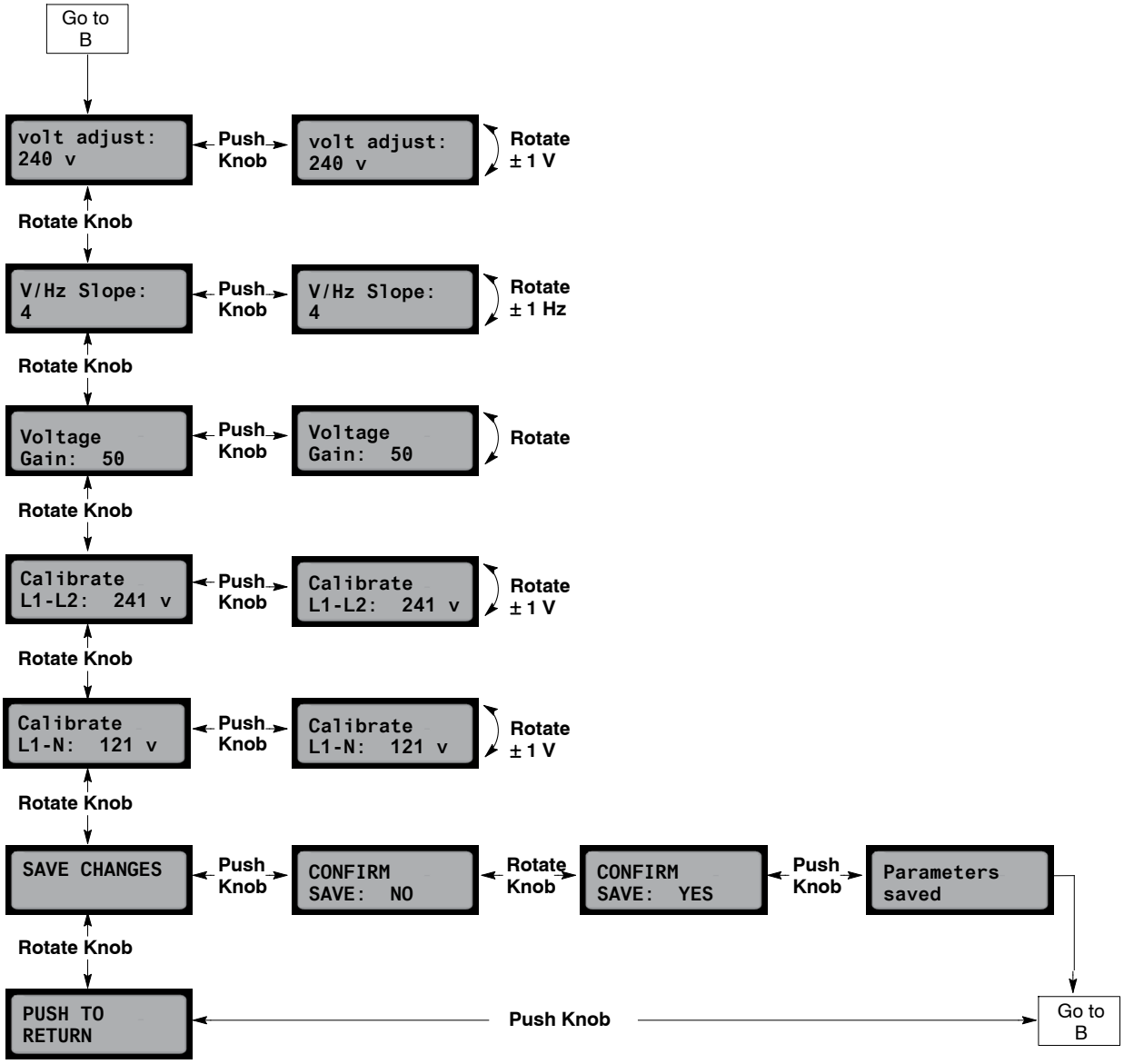


Figure 4-18 Advanced Digital Control, Runtime Adjustment Parameter (5/7.5/10EKD and 4/6/8EFKD Models)

USB Flow

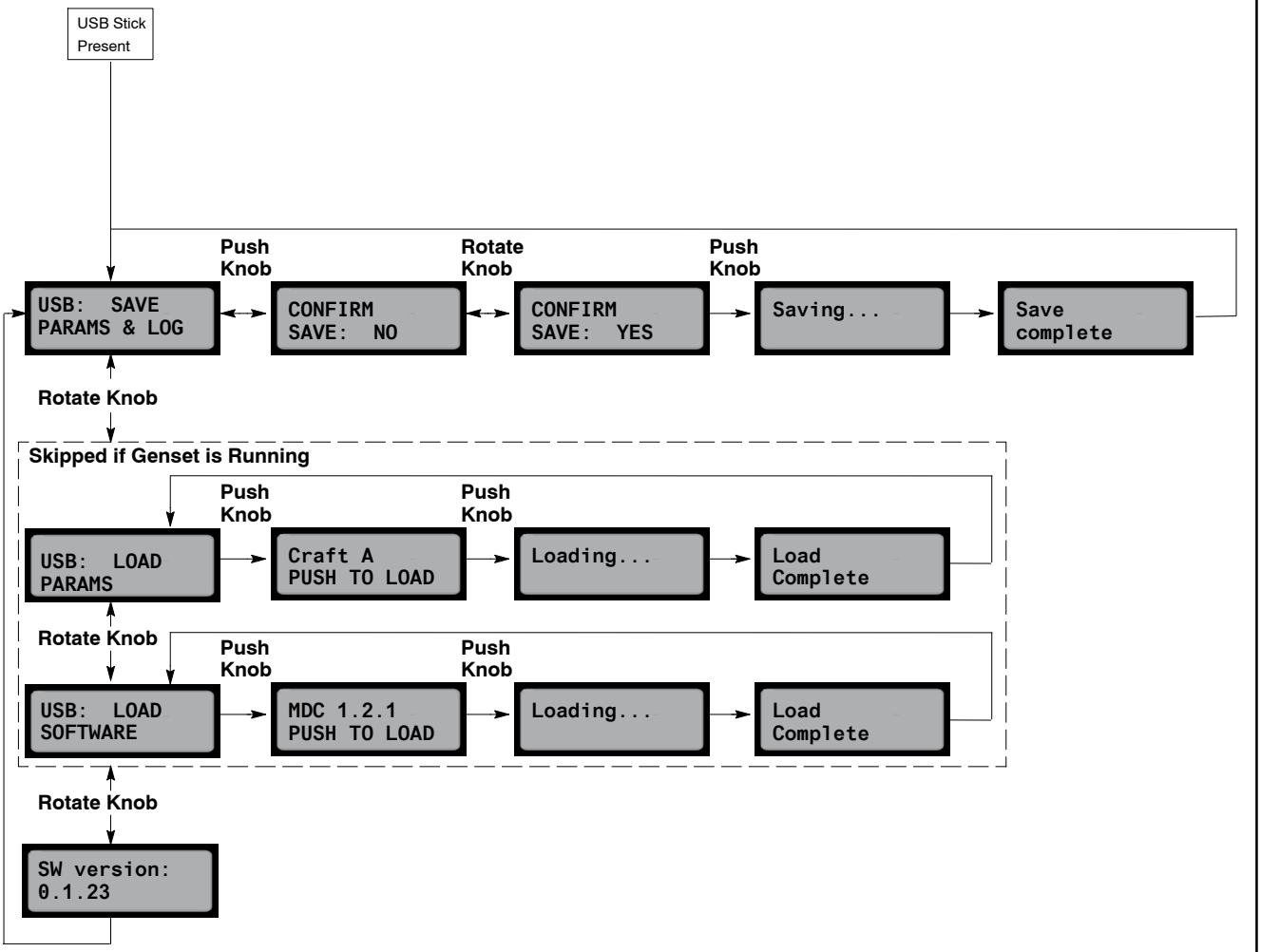


Figure 4-19 Advanced Digital Control, USB Flow (5/7.5/10EKD and 4/6/8EFKD Models)

Notes

5.1 Theory of Operation

Model 5/7.5/10EKD and 4/6/8EFKD generator sets utilize a rotating-field alternator to produce AC voltage. Upon activation of the generator start button, DC current from the battery magnetizes the rotor (field). When the magnetized rotor rotates within the stator windings, an electrical voltage develops within the stator. As engine speed and generator output increase, the ADC II feeds rectified stator output current to the rotor through the brushes/slip rings to increase the strength of the rotor field. As the rotor field increases in strength, generator output also increases. The ADC II controller monitors the generator output voltage through leads 11 and 44 and adjusts the DC current to the rotor to meet load requirements. See Figure 5-2.

5.2 Separate Excitation

To determine the cause of no or low AC output, refer to the troubleshooting flow chart in Figure 5-1. Before beginning the test procedures, read all safety precautions at the beginning of this manual. Many of the test procedures include additional safety precautions.

Check the condition of the alternator fuse (F5) before performing the separate excitation procedure. See Figure 5-2. See Figure 1-2 for the fuse location. If the fuse is not blown, use the following procedure to separately excite the generator using an external voltage source (a 12-volt automotive battery).

Separately exciting the generator can identify faulty voltage regulation by the ADC II controller or reveal a running fault in the rotor and/or stator. An external power source duplicates the role of the voltage regulator and excites the generator field (rotor). A generator component that appears to be in good condition while stationary may exhibit a running open or short circuit while moving. Centrifugal forces acting on the windings during rotation cause a broken circuit to open, or increasing temperatures cause the insulation to break down, resulting in a running fault.

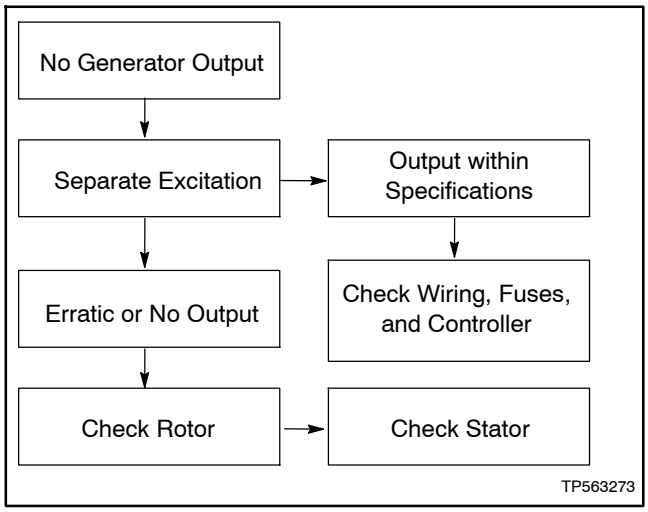


Figure 5-1 Generator Troubleshooting

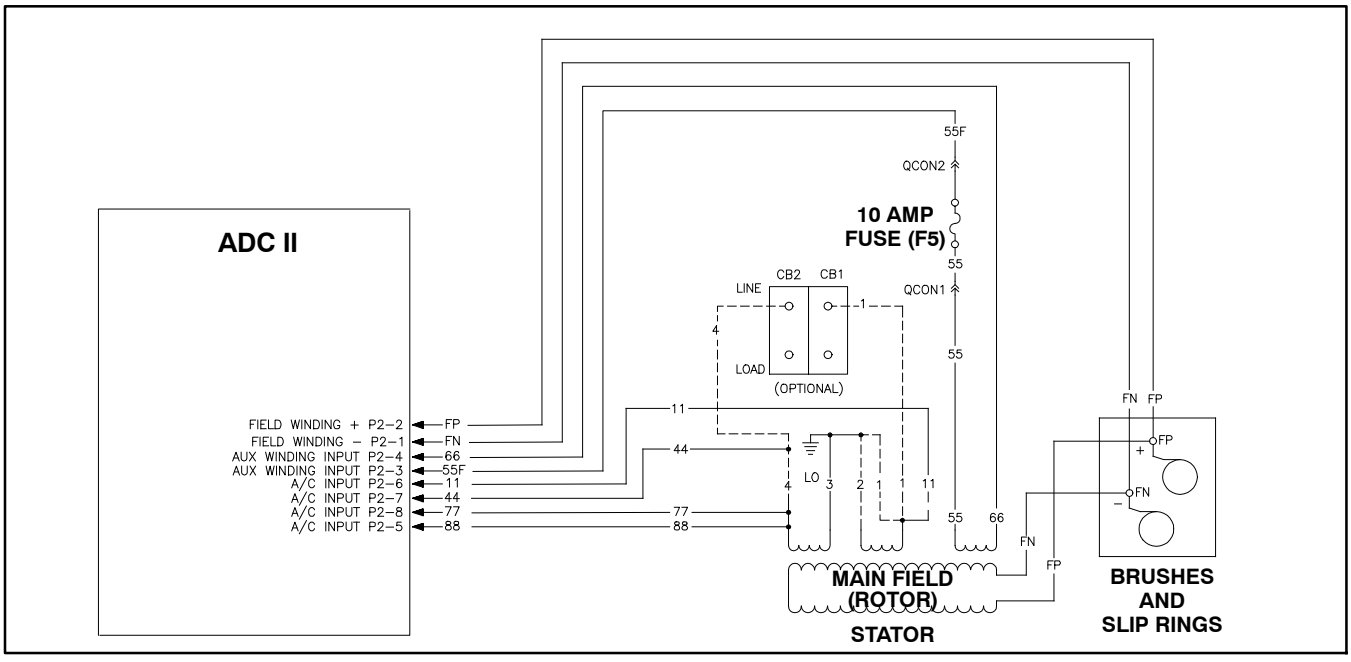
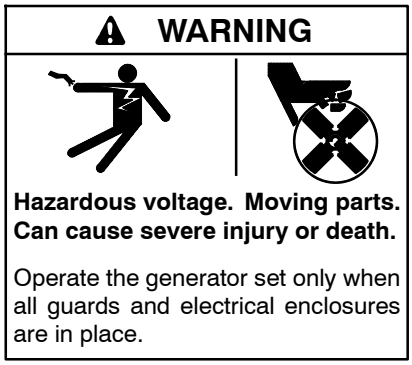


Figure 5-2 Generator Schematic



Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Separate Excitation Procedure

Perform the following procedure to use an external voltage source to excite the main field (rotor).

1. Remove the junction box cover and disconnect the black FN and FP leads (from the alternator).

2. Connect a DC ammeter, 10-amp fuse, and a 12-volt automotive battery to the positive (FP) and negative (FN) brush leads as shown in Figure 5-3. Note and record the ammeter reading.

   Note: The approximate ammeter reading should be the battery voltage divided by the specified rotor resistance. See Section 1, Specifications, for specified rotor resistance values.

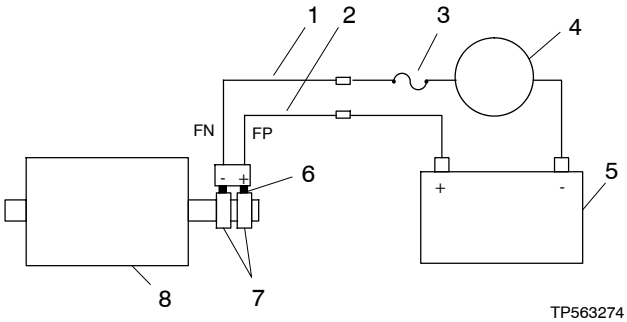
   Example:

   $$\frac{\text{12 volts (battery voltage)}}{\text{3.4 ohms (rotor resistance)}} = \text{3.5 amps (rotor current)}$$

3. Start the engine and check that the ammeter reading remains stable. An increasing meter reading indicates a shorted rotor. A meter reading decreasing to zero or an unstable reading suggests a running open. Refer to Section 5.4, Main Field (Rotor), to test the rotor. If the ammeter reading is stable, proceed to step 4.

4. Check for AC output across the stator leads; see Section 5.3, Stator. Compare the readings to the AC output values shown in Section 1, Specifications. If the readings vary considerably, a faulty stator is likely. Refer to Section 5.3, Stator, for further information.

5. If this test shows that the rotor and stator are in good condition, check the wiring and fuses. Check the controller settings and connections. See Section 4, Controller.



1. FN lead (disconnected in step 1)
2. FP lead (disconnected in step 1)
3. 10-amp fuse
4. DC ammeter
5. 12V battery
6. Brushes
7. Slip rings
8. Main field (rotor)

Figure 5-3 Separate Excitation Connections

5.3 Stator

The stator contains a series of coils of wire laid in a laminated steel frame. The stator leads supply AC voltage to the load and voltage regulator. Before testing the stator, inspect it for heat discoloration and visible damage to housing lead wires, exposed coil windings, and exposed areas of frame laminations. Be sure the stator is securely fastened to the stator housing.

Note: Disconnect all stator leads before performing all stator tests.

⚠ WARNING

Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Stator Continuity and Resistance Tests

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (–) lead first.
4. Disconnect all stator leads before performing all stator tests.
5. To check for stator continuity, set the ohmmeter on R x 1 scale. First set the ohmmeter zero by holding the red and black meter leads together and setting the ohmmeter reading to zero. Then check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 5-4.

   Note: For single-phase models, leads 1–4 are the generator output leads. Leads 11, 44, 55, and 66 are the controller sensing and supply leads. Refer to the schematic in Figure 5-5 when performing the following steps.

   Note: When taking an ohmmeter reading using lead 55, make the connection before the in-line fuse.

6. Contact the ohmmeter leads and readjust the ohmmeter to read zero ohms.
7. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads. See Section 1.4, Alternator Specifications, for stator winding resistances.

   Note: Most ohmmeters do not provide accurate readings below 1 ohm. Low resistance readings (continuity) and no evidence of shorted windings (heat discoloration) indicate a stator in good condition. See Figure 5-6.

8. If the resistance test proves inconclusive, use a megohmmeter to test the stator as described in the next step.

   Note: Because ohmmeter accuracy varies, resistance readings are approximate readings. Take readings of the rotor and stator at room temperature.

   Note: Make sure that all stator leads are disconnected before running the megohmmeter test.

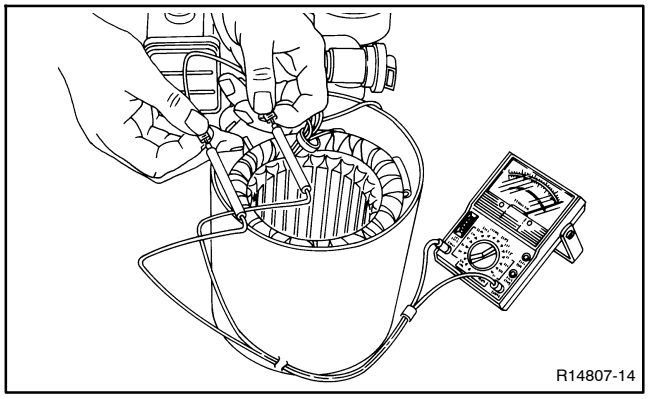


Figure 5-4 Testing Stator Windings

9. Use a megohmmeter to determine whether the stator is shorted to ground.

   a. Apply 500 volts DC to any stator lead and the stator frame. Perform the megohmmeter test following the instructions of the megohmmeter manufacturer.

   b. Repeat the test on the other stator leads until each coil is tested.

      Note: A reading of approximately 500 kOhms (1/2 megohm) and higher indicates a good stator.

   c. Repair or replace the stator if any reading is less than approximately 500 kOhms. A reading of less than 500 kOhms indicates deterioration of the winding insulation and possible current flow to ground.

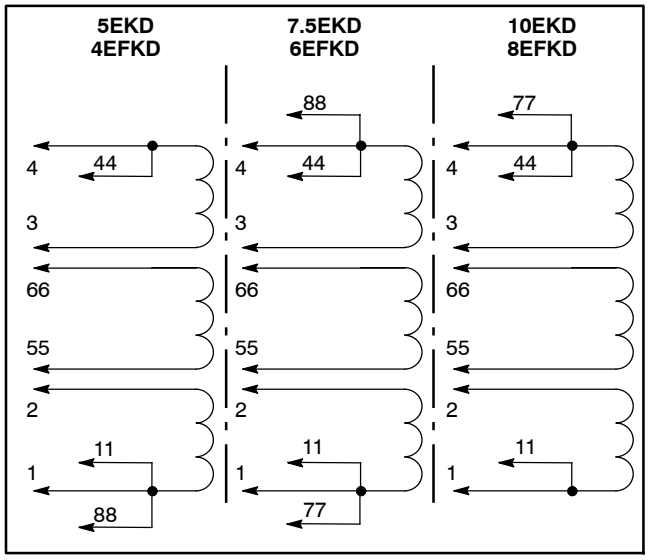


Figure 5-5 Single-Phase Alternator Stator Leads

Leads	Continuity
1 and 2	Yes
1 and 11	
1 and 88 (for 5EKD/4EFKD models)	
1 and 77 (for 7.5EKD/6EFKD models)	
2 and 11	
3 and 4	
3 and 44	
4 and 44	
4 and 88 (for 7.5EKD/6EFKD models)	
4 and 77 (for 10EKD/8EFKD models)	
55 and 66	
1 and 3, 4, 44, 55, or 66	No
2 and 3, 4, 44, 55, or 66	
3 and 1, 2, 11, 55, or 66	
4 and 1, 2, 11, 55, or 66	
Any stator lead and ground on stator housing or frame laminations	

Figure 5-6 Continuity Test Results on a Good Stator (Single-Phase)

5.4 Main Field (Rotor)

The two-pole rotor creates the magnetic field needed to produce alternating current in the stator windings. Before testing, inspect the rotor for visible damage to pole shoes, insulation, exposed coil windings, and slip ring surfaces. Rotate the bearing to check for wear, heat discoloration, or noise.

5.4.1 Rotor Continuity and Resistance Tests

⚠ WARNING

Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Rotor Test Procedure

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (–) lead first.
4. Remove the brush cover from the alternator end bracket.
5. Check the rotor for continuity and resistance. Raise the brushes from the slip rings while performing ohmmeter tests. Measure the rotor resistance (ohms) between the two slip rings; see Figure 5-7. See Section 1.4, Alternator Specifications, for rotor resistance readings. If the resistance readings are low, perform a megohmmeter test on rotor as described in the next step.

   Note: Because ohmmeter accuracy varies, resistance readings are approximate. Take readings at room temperature.

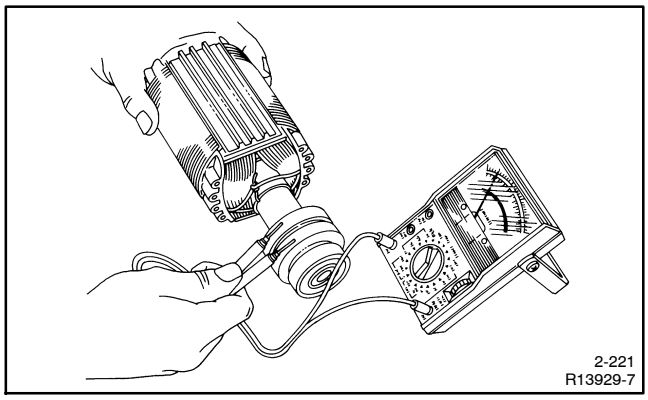


Figure 5-7 Rotor Resistance Check

6. Perform a megohmmeter test to determine whether the rotor is shorted to ground.

   a. Raise and secure the brushes away from the slip rings by inserting a retaining wire in the brush holder hole.

   b. Using a megohmmeter, apply 500 volts DC to one rotor slip ring and the rotor poles or shaft. Follow the instructions of the megohmmeter manufacturer when performing this test.

      Note: A reading of approximately 500 kOhms (1/2 megohm) or higher indicates a good rotor.

   c. Repair or replace the rotor if the reading is less than approximately 500 kOhms. A reading of less than 500 kOhms indicates deterioration of the winding insulation and possible current flow to ground.

   d. Following the test, remove the retainer wire from the brush holder and check the brush positions on the slip rings. See Section 5.6, Brushes.

   e. Reinstall the brush cover on the end bracket.

5.5 Slip Rings

Slip rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly-machined appearance on the slip rings. Cleaning with a dry, lint-free cloth is usually sufficient. Use very fine sandpaper (#00) and apply light pressure to remove roughness. Do not use emery or carborundum paper or cloth. Clean all carbon dust from the generator after sanding the slip rings. If the rings are black or pitted, remove the rotor and use a lathe to remove some of the slip ring surface material.

5.6 Brushes

The brushes transfer current from the ADC II to the slip rings. The brushes should last the life of the generator. Abrasive dust on the slip rings, however, shortens the life of the brushes. Excessive arcing at the brushes could damage the ADC II and the controller. Weak springs, damaged slip rings, sticking brushes, a loose brush holder, or poor brush contact causes arcing.

The brushes must be free to move within the holder and be held in contact with the slip rings by the springs. When correctly positioned, spring pressure on the brush surface causes the brush to wear evenly. The entire brush must ride on the ring or arcing occurs and causes burned rings or voltage regulator failure. Figure 5-8 shows the correct positioning of the brushes. Add or remove shims as necessary to center the brushes on the slip rings. Replace the brushes if they show uneven wear or are worn to one half their original length.

Check the resistance through the brushes. Resistance through the brushes should be low, 0.1–0.2 ohms without meter lead resistance.

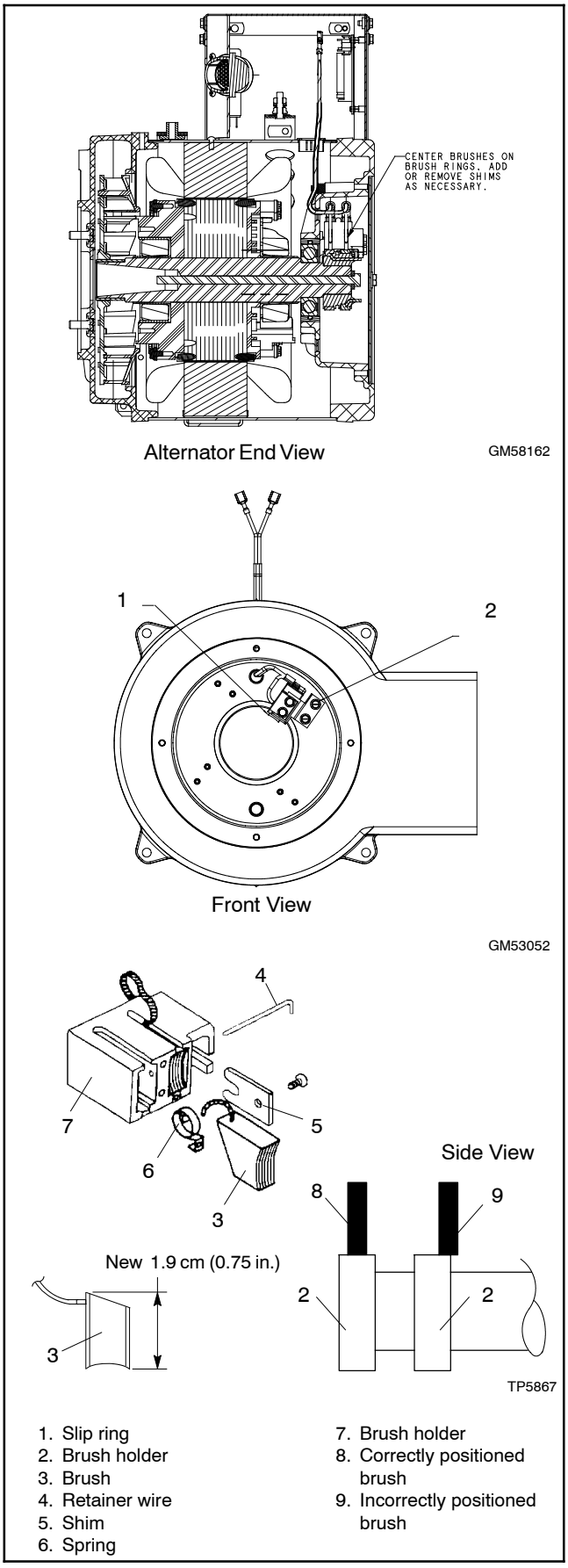


Figure 5-8 Brush Assembly

5.7 Voltage Reconnection

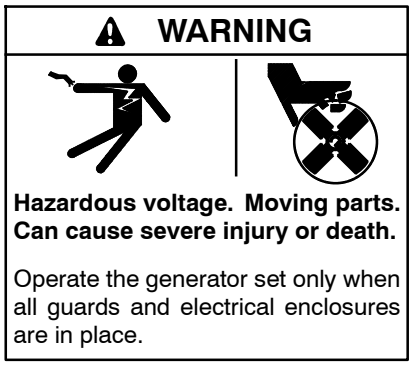
Voltage Reconnection is covered in the generator set Installation Manual. See the List of Related Materials for the document number.

5.8 Governor System

The frequency of the alternator output is determined by the speed of the engine. A two-pole alternator must be driven at 3600 RPM to provide 60 Hertz and 3000 RPM to provide 50 Hertz. The engine speed is maintained by the ADC II.

5.9 Fault Shutdown Tests

Verify the operation of the generator set shutdowns by performing the following tests. If these tests are inconclusive, test individual shutdown circuit components (wiring harness, switch, etc.) as described elsewhere in this section.



Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Overcrank Shutdown

Temporarily remove power to both the low pressure and high pressure pumps. Press the power button to turn the controller on. Press the start/stop button to start the generator set. Observe that the generator set simulates cranking for 7 seconds and then rests for 15 seconds. Check that the generator set shuts down after the third crank/rest cycle.

High Engine Temperature Shutdown

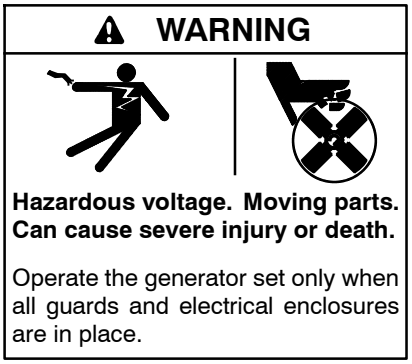
Remove the connector from the coolant temperature sensor (CTS). Attempt to start the generator set. The unit should not start and the ADC II control should display fault **ECT input hi**. To clear the fault, see Section 4.2.6.

Connect a jumper wire across terminals A and B of the connector, shorting the wires. Attempt to start the generator set. The unit should start and run but the ADC II should display warning code **ECT input lo**. Shutdown the generator set.

If available, insert a resistor (100–120 Ohm) into the CTS connector. Attempt to start the generator set. Shortly after ignition, the unit should shut down and the ADC II control should display fault code **Hi eng temp**. Replace the CTS connector onto the coolant temperature sensor. To clear the fault, see Section 4.2.6.

5.9.1 Fault Shutdown Switches/Senders

Check the low oil pressure and high engine temperature shutdown switches on the engine by performing the following tests. If the sensor does not function as described, replace it.



Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

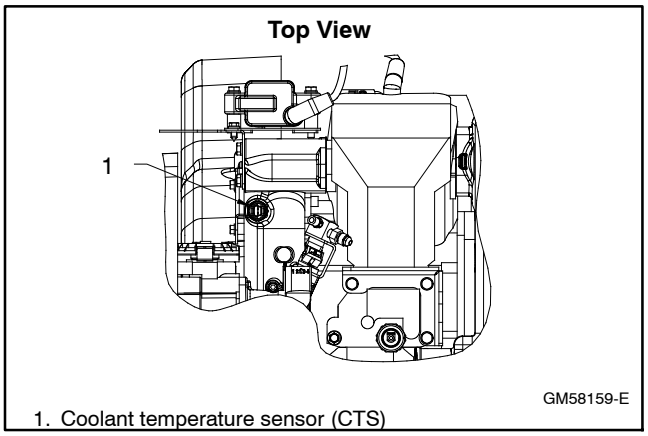
Temperature Sensor (CTS)

The coolant temperature sensor (CTS) is used to monitor engine temperature for the high engine

temperature fault shutdown (**Hi eng temp**). See Figure 5-10 for the coolant temperature sensor location. Shutdown the generator set, disconnect the battery (negative lead first), and allow the generator set to cool. Disconnect the CTS and use an ohmmeter to measure the resistance across the sensor. The sensor resistance varies with temperature and should be within the values shown in Figure 5-9. If the resistance is very low (indicating a short circuit) or very high (indicating an open circuit) replace the CTS.

Temperature, °C (°F)	Sensor Resistance, Ohms	Signal Voltage
100 (212)	177	0.75
90 (194)	241	0.97
80 (176)	332	1.25
70 (158)	467	1.59
60 (140)	667	2.00
50 (122)	973	2.47
40 (104)	1459	2.97
30 (86)	2238	3.46
20 (68)	3520	3.89
10 (50)	5670	4.25
-40 (-40)	100700	4.95

Figure 5-9 Coolant Temperature Sensor Resistance Readings



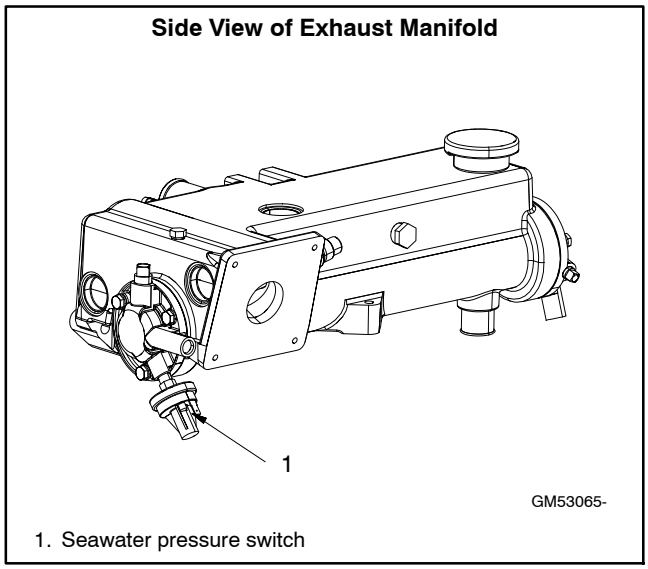
1. Coolant temperature sensor (CTS)

Figure 5-10 Coolant Temperature Sensor (CTS)

Seawater Pressure Switch

See Figure 5-11. Remove the seawater pressure switch and install a pressure gauge to verify that the seawater pressure is within the range specified before testing or replacing the seawater pressure switch. To test the seawater pressure switch, reinstall the switch and start the generator set. If the unit shuts down, disconnect lead 87 from the seawater pressure switch and reset the controller. Restart the generator set and verify that it does not shut down. A successful restart indicates a bad seawater pressure switch. Replace the switch.

The calibration pressure of the seawater pressure switch is 2.0 psi ± 0.5.



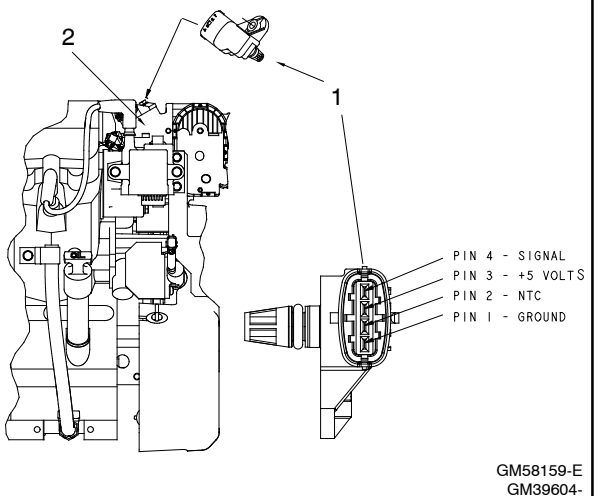
1. Seawater pressure switch

Figure 5-11 Seawater Pressure Switch Location

TMAP Sensor

The TMAP sensor monitors intake manifold temperature and pressure. This allows the ADC II full control to monitor actual airflow compared to desired airflow. The TMAP sensor incorporates both intake manifold temperature and pressure measurements in one, single unit. See Figure 5-12 for the TMAP sensor location.

To test the TMAP sensor, shutdown the generator set, disconnect the battery (negative lead first), and allow the generator set to cool. Disconnect the TMAP sensor and use an ohmmeter to measure the resistance across the sensor. The sensor resistance varies with temperature and should be within the values shown in Figure 5-14. If the resistance is very low (indicating a short circuit) or very high (indicating an open circuit) replace the TMAP sensor.



1. TMAP Sensor
2. Intake manifold assembly

Figure 5-12 TMAP Sensor Location

Thermal Characteristics Nominal			
Temperature, °C (°F)	**Sensor Resistance, Ohms**	**Temperature, °C (°F)**	**Sensor Resistance, Ohms**
130 (266) ± 1	85.45	45 (113) ± 1	1008.6
125 (257) ± 1	96.68	40 (104) ± 1	1199.6
120 (248) ± 1	109.65	35 (95) ± 1	1431.8
115 (239) ± 1	124.66	30 (86) ± 1	1715.4
110 (230) ± 1	142.08	25 (77) ± 1	2062.9
105 (221) ± 1	162.35	20 (68) ± 1	2510.6
100 (212) ± 1	186.00	15 (59) ± 1	3074.9
95 (203) ± 1	213.68	10 (50) ± 1	3791.1
90 (194) ± 1	246.15	5 (41) ± 1	4706.9
85 (185) ± 1	284.06	0 (32) ± 1	5886.7
80 (176) ± 1	329.48	-5 (23) ± 1	7419.0
75 (167) ± 1	382.89	-10 (14) ± 1	9426.0
70 (158) ± 1	466.33	-15 (5) ± 1	12078
65 (149) ± 1	521.91	-20 (-4) ± 1	15614
60 (140) ± 1	612.27	-25 (-13) ± 1	20376
55 (131) ± 1	720.65	-30 (-22) ± 1	26855
50 (122) ± 1	851.10	-35 (-31) ± 1	35763

Figure 5-13 TMAP Sensor Resistance Readings

TMAP Sensor Pin Resistance Check	
TMAP Pin 1 (GND) to Pin 4 (PRESSURE SIGNAL KPA)	2.4 - 8.2 kOhms
TMAP Pin 3 (PWR) to Pin 4 (PRESSURE SIGNAL KPA)	3.4 - 8.2 kOhms
TMAP Pin 1 (GND) to Pin 2 (TEMPERATURE SIGNAL)	See Figure 5-13

Figure 5-14 TMAP Sensor Resistance

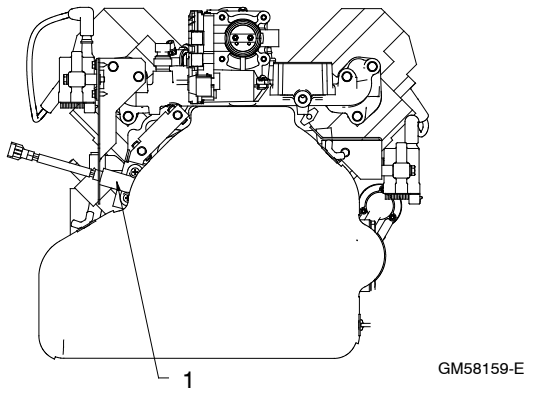
Max. Ratings of TMAP Sensor	
Supply voltage	16 volts
Pressure	500 kPa

Crankshaft Position Sensor

The crankshaft position sensor monitors speed control, timing (firing of spark plugs), and fuel injection. See Figure 5-15 for the crankshaft position sensor location. The crankshaft position sensor is an electromagnetic device which contains a permanent magnet surrounded by a winding. The sensor is used with the timing wheel at a precise location to allow the ADC II a very accurate speed reference signal. The timing wheel rotation near the sensor's tip changes the magnetic flux, creating an analog voltage signal in the sensor coil.

The spark is sent to the appropriate cylinder via the spark plug wires. The ADC II uses the signal from the crankshaft position sensor to determine the engine position and RPM. This information, together with the TPS and TMAP sensor information is used to calculate the correct ignition timing settings.

To test the crankshaft position sensor, shutdown the generator set, disconnect the battery (negative lead first), and allow the generator set to cool. Disconnect the crankshaft position sensor and use an ohmmeter to measure the resistance across the sensor pins. See Figure 5-17.



1. Crankshaft position sensor

Figure 5-15 Crankshaft Position Sensor Location

Model	Crankshaft Position Sensor Gap (between sensor and flywheel)
All	0.76–1.52 mm (0.030–0.045 in.)

Figure 5-16 Crankshaft Position Sensor Gap

Crankshaft Position Sensor Pin Resistance (approx.)	
Pin 1 (+) to Pin 2 (–)	320 Ohms

Figure 5-17 Crankshaft Position Sensor Resistance Check

Ignition Coil

This system uses two ignition coils that receive firing signals from the controller's microprocessor. See Figure 5-18. The microprocessor signals the coils to begin their cycle. Then the coils wait for the trigger signal from the microprocessor.

To test the ignition coils, shutdown the generator set, disconnect the battery (negative lead first), and allow the generator set to cool. Disconnect the ignition coils and use an ohmmeter to measure the resistance across the coil pins. See Figure 5-19 for the coil resistance.

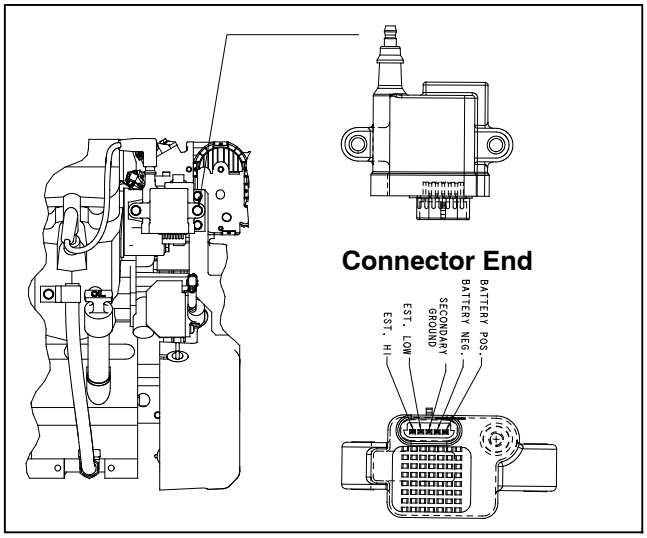


Figure 5-18 Ignition Coil (Service Side Shown)

Ignition Coil Pin Resistance Check (approx.)	
Pin A (SIGNAL) to Pin B	10 kOhms
Pin A (SIGNAL) to Pin D	34 kOhms
Pin A (SIGNAL) to Pin E (PWR)	15 kOhms
Pin B to Pin D	44 kOhms
Pin B to Pin E (PWR)	26 kOhms
Pin D to Pin E (PWR)	17 kOhms

Figure 5-19 Ignition Coil Resistance Check

Heated Oxygen (O_2) Sensor

The heated oxygen sensor is used to monitor O_2 in the exhaust. See Figure 5-21 for the heated oxygen sensor location.

Note: The heated oxygen sensor is calibrated to work with this system. Do not use alternate sensors.

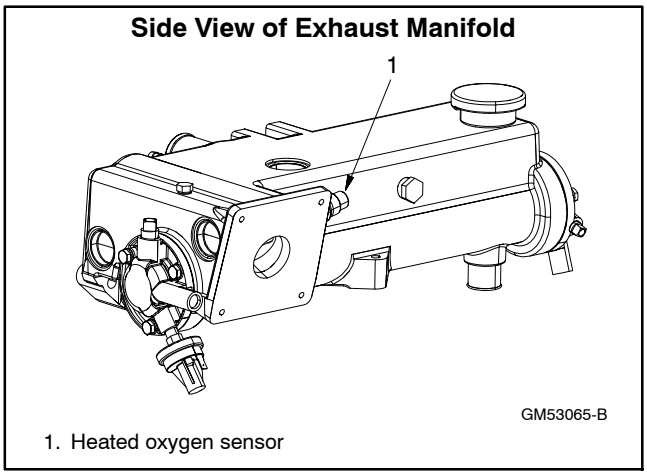
The oxygen sensor operates like an electrolyte with its platinum layers serving as electrodes. After the internal element reaches approx. 600° F, it becomes electrically conductive and attracts negatively charged ions of oxygen. These ions collect on the inner and outer platinum surfaces.

A heater element is added to the sensor housing in order for the sensor to conduct and create an electrical signal below 600° F. Two wires provide 12VDC and a ground signal for the heater element. A fourth wire provides an independent ground for the sensor. The targeted air/fuel ratio signal is approx. 500mV and changes slightly based on speed and load conditions. When the sensor sends a voltage signal less than 500mV, the ADC II interprets the air/fuel mixture as lean so the ADC II increases the duty cycle of the fuel injector. If the ADC II receives a voltage signal above 500mV, the air/fuel mixture would be interpreted as too rich and the ADC II would decrease the duty cycle of the fuel injector.

Shutdown the generator set, disconnect the battery (negative lead first), and allow the generator set to cool. Disconnect the heated oxygen sensor and use an ohmmeter to measure the resistance across the sensor pins. See Figure 5-20.

O_2 Sensor Pin Resistance Check	
Pin C (HEATER GND) to Pin D (HEATER PWR)	2.1 ± 0.4 Ohms

Figure 5-20 O_2 Sensor Resistance

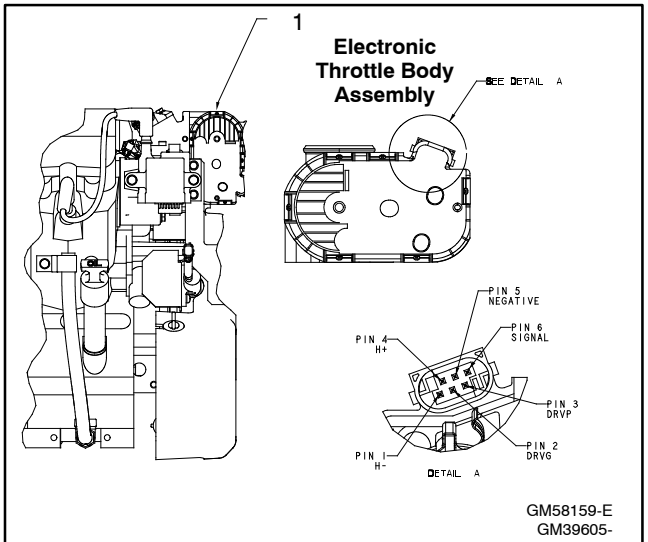


1. Heated oxygen sensor

Figure 5-21 Heated Oxygen Sensor Location

5.10 Electronic Throttle Assembly

The electronic throttle body assembly (ETC) contains the throttle valve, throttle valve actuator, and throttle position sensor (TPS1). The ADC II calculates the correct throttle valve opening, makes any adjustments, and then generates an electrical signal to the throttle-valve actuator. The ADC II calculates the correct throttle position based on RPM and MAP and compares this to the actual throttle position based on TPS1. The ADC II continuously checks and monitors all sensors and calculated data. If no redundant signal is available or the calculated data cannot solve the malfunction, the ADC II shuts the engine down, storing the fault information in the ADC II.



1. Electronic throttle body assembly

Figure 5-22 Electronic Throttle Body Assembly

Shutdown the generator set, disconnect the battery (negative lead first), and allow the generator set to cool. Disconnect the TPS sensor and use an ohmmeter to measure the resistance across the sensor pins. See Figure 5-23.

TPS (Electronic Throttle) Sensor Pin Resistance Check (approx.)	
Pin 2 (GND) to Pin 6 (TPS1 SIGNAL)	1.25 kOhms ± 30%
Pin 3 (PWR) to Pin 6 (TPS1 SIGNAL)	1.25 kOhms ± 30%
Pin 1 (+DRIVER) to Pin 4 (–DRIVER)	3.0 Ohms ± 30%

Figure 5-23 TPS (Electronic Throttle) Sensor Resistance

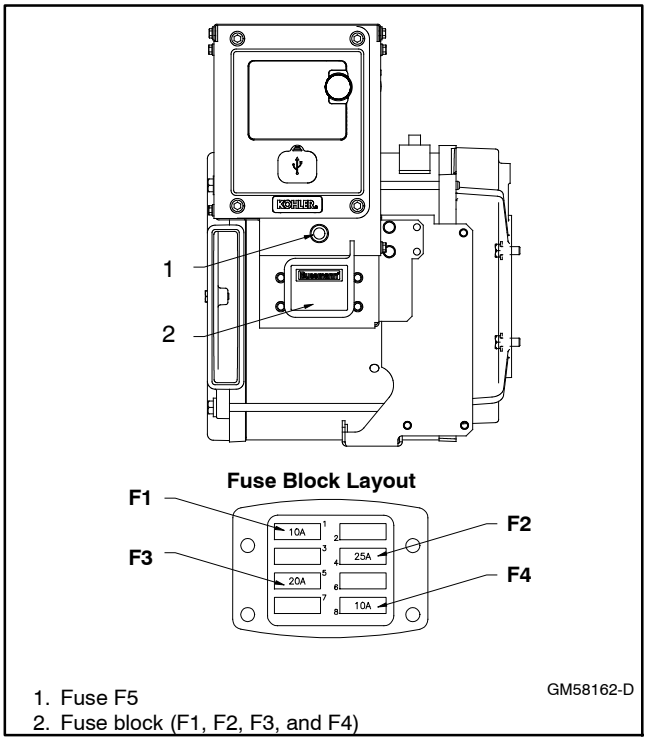
5.11 Fuses

See Figure 5-24 for fuse ratings and part numbers.

Always identify and correct the cause of a blown fuse before restarting the generator set. Refer to Section 3, Troubleshooting, for conditions that may indicate a blown fuse. Replace blown fuses with identical replacement parts.

Schematic Diagram Fuse Reference Number	Location	Fuse	Amps	Part Number
F1	Fuse block, position 1	Customer connection	10	GM42337
F2	Fuse block, position 4	Voltage regulator	25	GM42339
F3	Fuse block, position 5	Injector, CO sensor, fuel pumps, oxygen sensor, and coils	20	GM47427
F4	Fuse block, position 8	Controller	10	GM42337
F5	Fuse holder	Auxiliary winding	10	358337

Figure 5-24 Fuses



1. Fuse F5
2. Fuse block (F1, F2, F3, and F4)

Figure 5-25 Fuse Location

5.12 Continuity Checks

⚠ WARNING

Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Note: Disconnect the generator set battery before performing continuity checks to prevent damage to the ohmmeter.

To further check generator set components, disconnect the battery and remove wiring harness plugs from the controller circuit board. Refer to the wiring diagrams in Section 7, and use an ohmmeter to check for continuity and good ground connections. A zero reading on the ohmmeter indicates continuity. No ohmmeter reading indicates very high resistance or an open circuit.

Notes

6.1 Disassembly

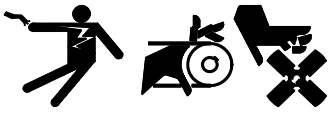
Disconnect all of the external connections—battery cables at the battery (negative (–) lead first), AC-output leads, remote interface connector. Close the seacock. Remove the water line at the seawater pump, fuel line at the fuel pump filter inlet, and exhaust line at the catalyst assembly. Remove the sound shield enclosure, if equipped. Observe all of the safety precautions listed at the beginning of this manual during the disassembly/reassembly procedures.

Note: Because this manual covers several models, the procedure for disassembly may vary because of product updates and the assembly variations.

Note: Mark leads that are disconnected. Refer to the wiring diagrams in Section 7 during reassembly.

1. Place the generator set master switch in the OFF position.
2. Disconnect power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (–) lead first.

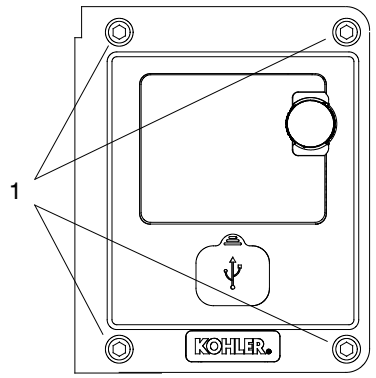
⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (–) lead first when disconnecting the battery. Reconnect the negative (–) lead last when reconnecting the battery.

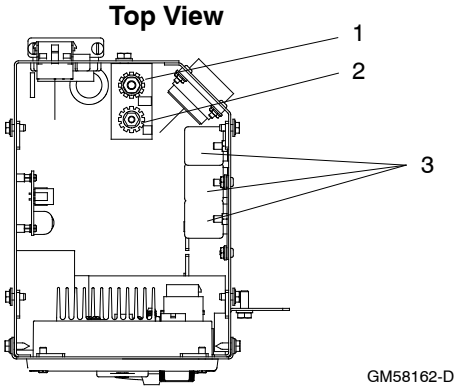
4. Disconnect wiring harness plugs P1 (35-pin plug) and P2 (8-pin plug) from the ADC II.
5. Loosen and remove the four controller mounting screws at the front of the controller. See Figure 6-1. Remove the controller.



1. Controller mounting screws (4)

Figure 6-1 ADC II Mounting Screws

6. Disconnect the generator output leads from the circuit breaker and disconnect QCON1 and QCON2 from the F5 fuse.
7. Disconnect the LO and GRD lead connections. See Figure 6-2.
8. Disconnect the FP and FN leads.
9. Remove the relays as necessary. See Figure 6-2.



1. Ground stud
2. LO stud
3. Relays (P23, P24, and P25)

Figure 6-2 ADC II Controller

10. Remove the junction box from the support bracket.

11. Disconnect the ground strap if necessary.

12. Remove the fuel inlet hose

13. Close the seacock and remove the water inlet hose from the seawater pump.

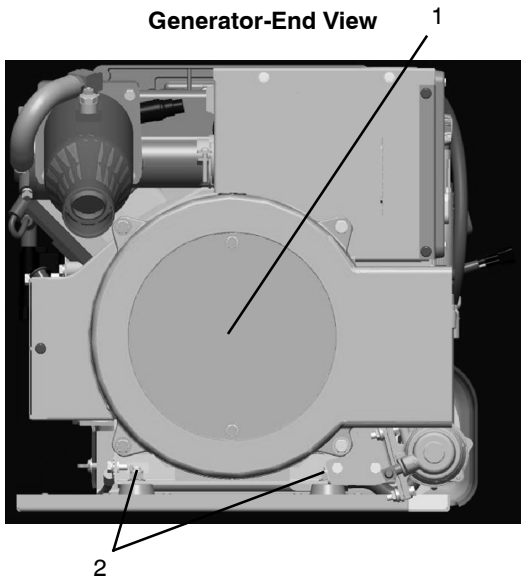
14. Remove the fuel pumps and lines from the generator.

15. Remove the end bracket cover plate. See Figure 6-3.

16. Push the brushes into the holder. Secure the brushes into position by sliding a retainer into the brush keeping holder. See Section 5.6.

17. Remove the brush holder and carefully pull the leads out of the stator housing. See Figure 6-6.

18. Remove the generator end vibromount hardware. See Figure 6-3.



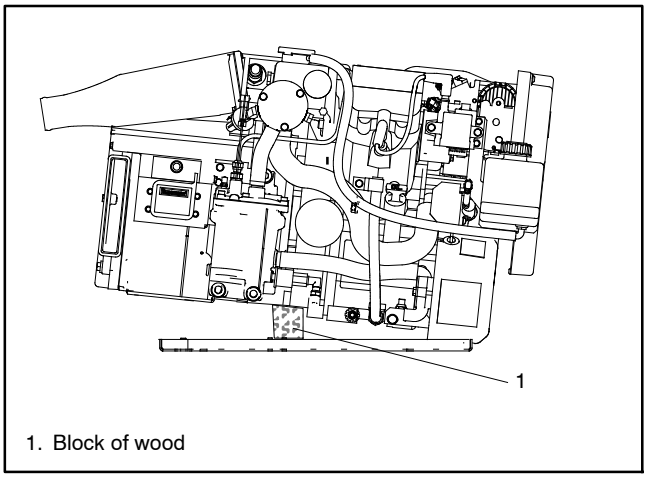
1. Alternator cover plate
2. Vibromount hardware

Figure 6-3 Alternator End Cover

19. Attach a hoist hook to the generator lifting eye.

    Note: The hoist capacity rating should be one-half ton or greater.

20. Tilt the generator set up and brace it with a block of wood. See Figure 6-4.



1. Block of wood

Figure 6-4 Raising the Generator

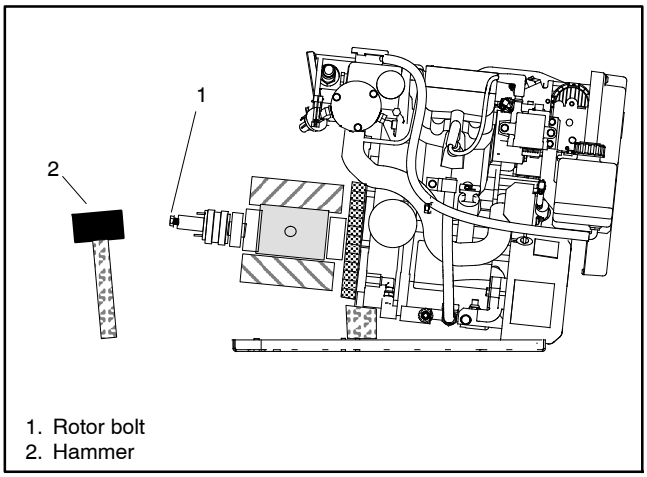
21. Remove the overbolts. See Figure 6-6. Use a rubber mallet to separate the end bracket from the stator housing.

22. Carefully remove the stator assembly from the generator adapter plate.

23. Remove the rotor bolt and end drive fitting.

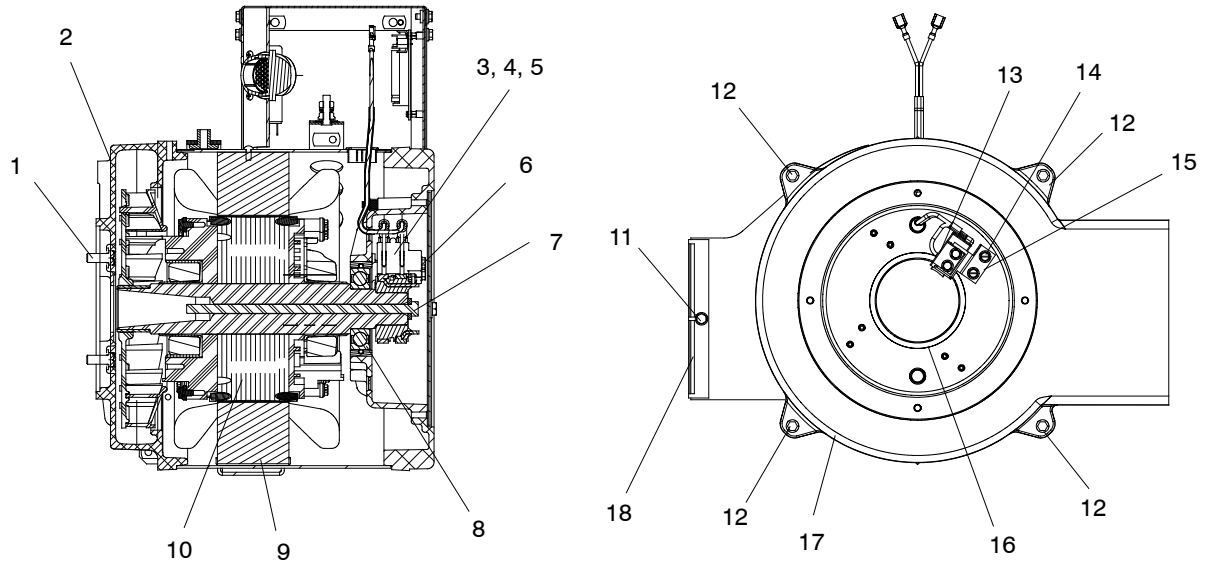
24. Reinstall the rotor bolt (without end fitting), finger tighten, and back off two turns.

25. Strike the bolt with a hammer until the rotor is freed from the engine's tapered drive shaft. Do not damage the through bolt threads or bolt head. See Figure 6-5.



1. Rotor bolt
2. Hammer

Figure 6-5 Removing the Rotor



1. Generator adapter bolt and washer, quantity 4
2. Generator adapter
3. Spring
4. Brush holder
5. Brush, quantity 2
6. Brush holder shim
7. Rotor thru bolt
8. End bracket bearing
9. Stator assembly
10. Rotor assembly
11. Fan guard screws, quantity 2
12. Generator overbolt, quantity 4
13. Retainer wire
14. Brush assembly mounting screws, quantity 2
15. Bracket, brush holder
16. O-ring
17. End bracket
18. Fan guard

Figure 6-6 Alternator Assembly Components

6.2 Collector Ring and Bearing Replacement

1. Unsolder the collector ring leads from the collector ring terminals.
2. Remove the collector rings with a three-jaw puller.
3. Remove the bearing with a three-jaw puller.
4. Press the new bearing onto the rotor shaft.
5. Align the collector ring keyway with the keyway on the rotor shaft. See Figure 6-8.
6. Press the new collector rings onto the rotor shaft.

Note: The new collector rings must be turned down to a finish of 32 micro inches using a lathe and commutator stones. Turn down the collector rings on the rotor shaft.

7. Solder the leads onto the collector ring terminals. The connection is not to exceed 9.5 mm (0.37 in.) beyond the collector rings. See Figure 6-8.
8. Test to ensure continuity at the collector rings.

Min. diameter mm (in.)	57.15 (2.250)
Max. finish	32 micro inches
Max. eccentricity mm (in.)	0.08 (0.003)
Max. out-of-round mm (in.)	0.01 (0.0002)

Figure 6-7 Collector Ring Dimensions

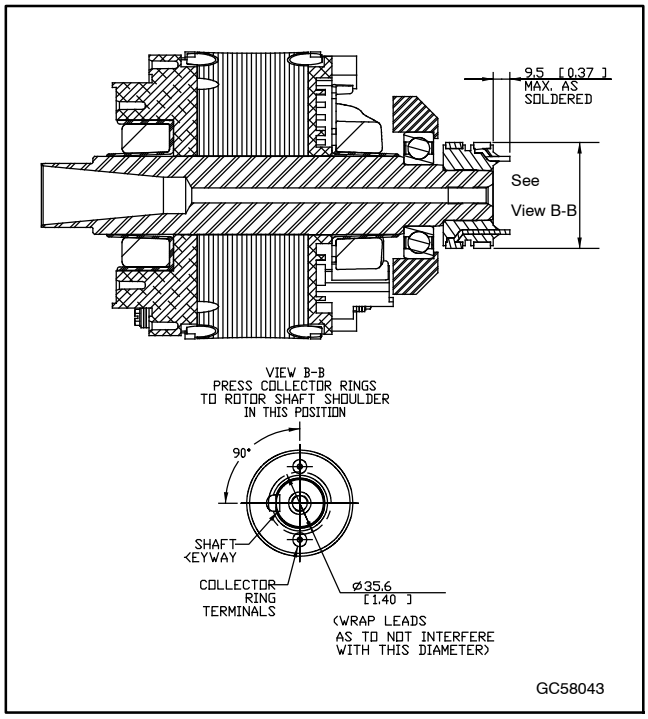


Figure 6-8 Rotor Assembly

6.3 Reassembly

Note: See Section 1.6 and Appendix C for torque specifications.

1. Align the rotor onto the engine shaft and secure with the end drive fitting and rotor bolt. Torque the rotor to 23.1 Nm (204 in. lbs.) for 5/7.5EKD and 4/6EFKD models or 32.5 Nm (288 in. lbs.) for 10EKD and 8EFKD models.
2. Carefully slide the stator assembly over the rotor.
3. Replace the end bracket o-ring into the groove in the end bracket bearing insert. See Figure 6-6.
4. Install the end bracket and torque the overbolts to 13.6 Nm (120 in. lbs).
5. Feed the brush leads inside the stator housing up through the opening. Secure the brush holder using the original screws.
6. Remove the brush retainer and check the brush alignment. See Section 5.6.
7. Install the coverplate and torque the coverplate bolts to 6.8 Nm (60 in. lbs.).
8. Use the hoist to raise the alternator end. Remove the wood block from under the locator plate. Lower the generator set and install a bolt, a large washer, two small washers, and a locknut on each vibromount. Tighten the mounting bolts.
9. Reinstall the relays.
10. Reinstall the support bracket to mount the junction box. See Figure 4-1.
11. Install tie wraps to secure the wires as necessary.
12. Reconnect the leads to the circuit breaker, QCON1 and QCON2 to the F5 fuse, FP and FN leads, neutral stud (LO), and ground stud (GRD) as marked during disassembly. Refer to the wiring diagrams in Section 7.

    Note: Check the generator set nameplate to verify the original voltage configuration.
13. Reinstall the ADC II.
14. Reconnect the P1 and P2 connectors. Connect the ground strap using bolt, washer, and lock washer (install the lock washer against the ground strap).
15. Reconnect all of the external connections—the exhaust line to the catalyst assembly, the fuel line to the fuel pump filter inlet, the water line to the seawater pump, the remote interface connector, the AC output leads, and the battery cables to the battery (negative (–) lead last).
16. Verify that the generator set master switch is in the OFF position.
17. Reconnect the engine starting battery, negative (–) lead last.
18. Reconnect power to the battery charger, if equipped.

6.4 Exhaust Manifold/Heat Exchanger Instructions

See Figure 6-9 for special exhaust manifold/heat exchanger instructions, if required.

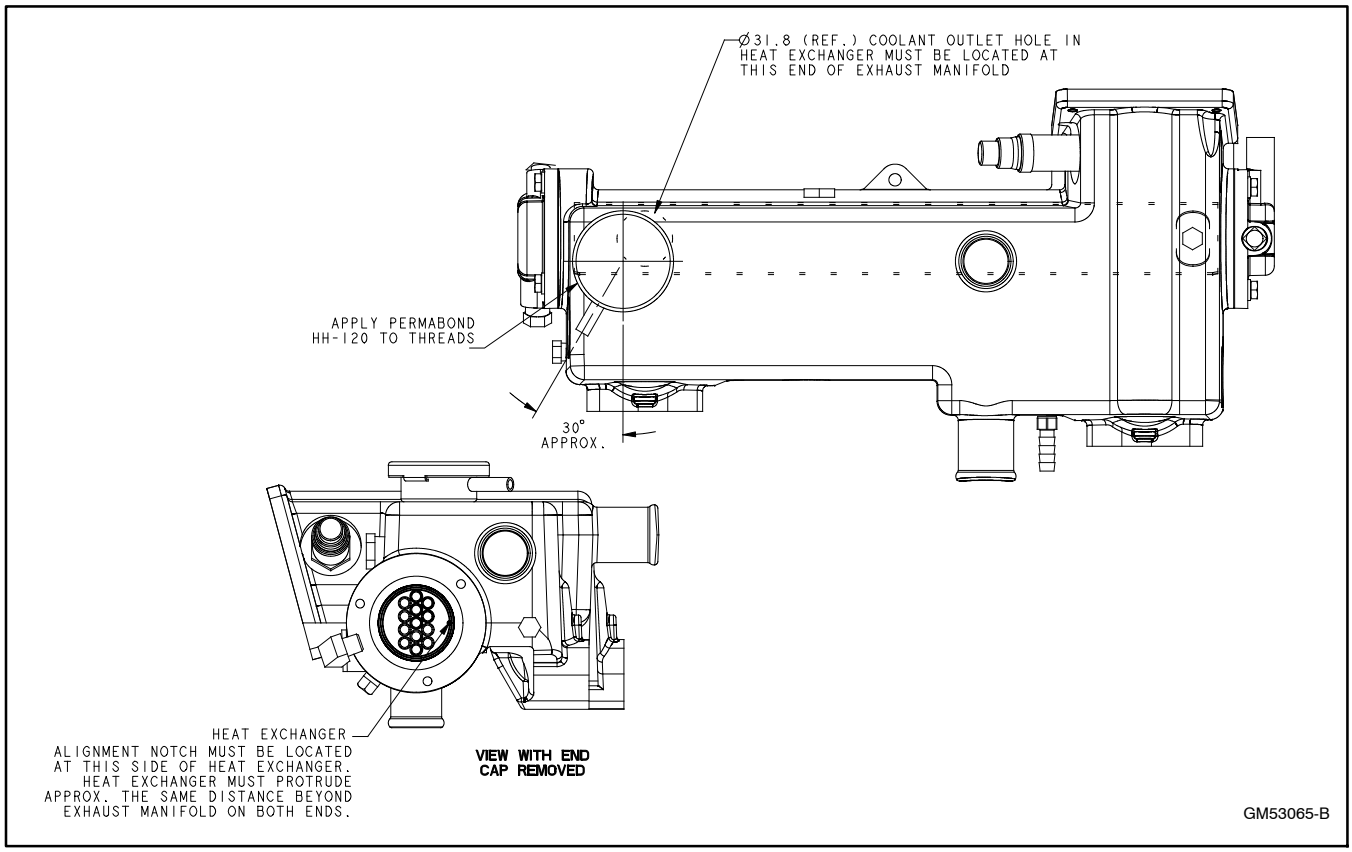
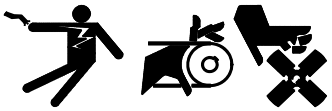


Figure 6-9 Exhaust Manifold

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

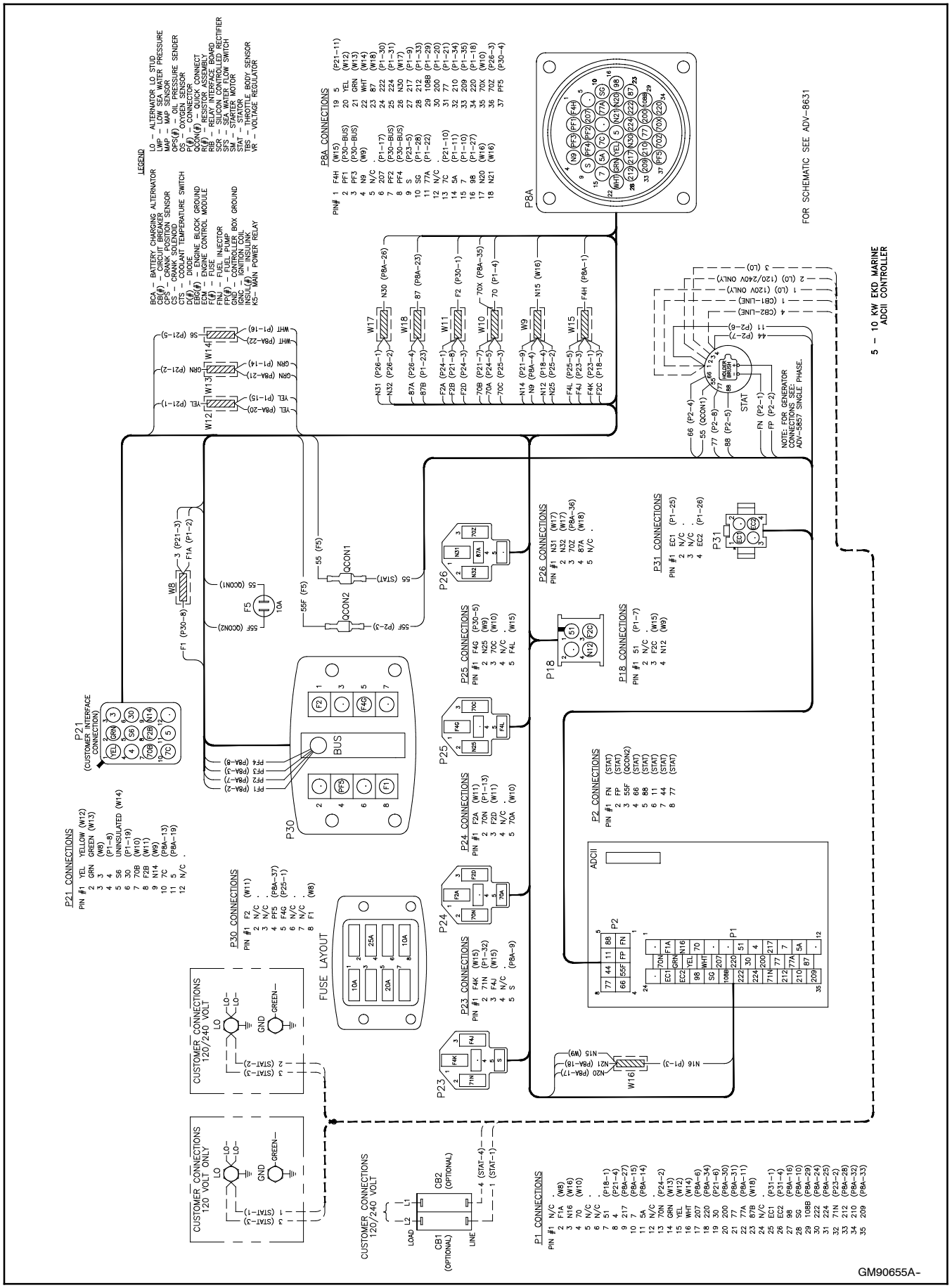


Figure 7-1 Point-to-Point Wiring Diagram (Sheet 1 of 2)

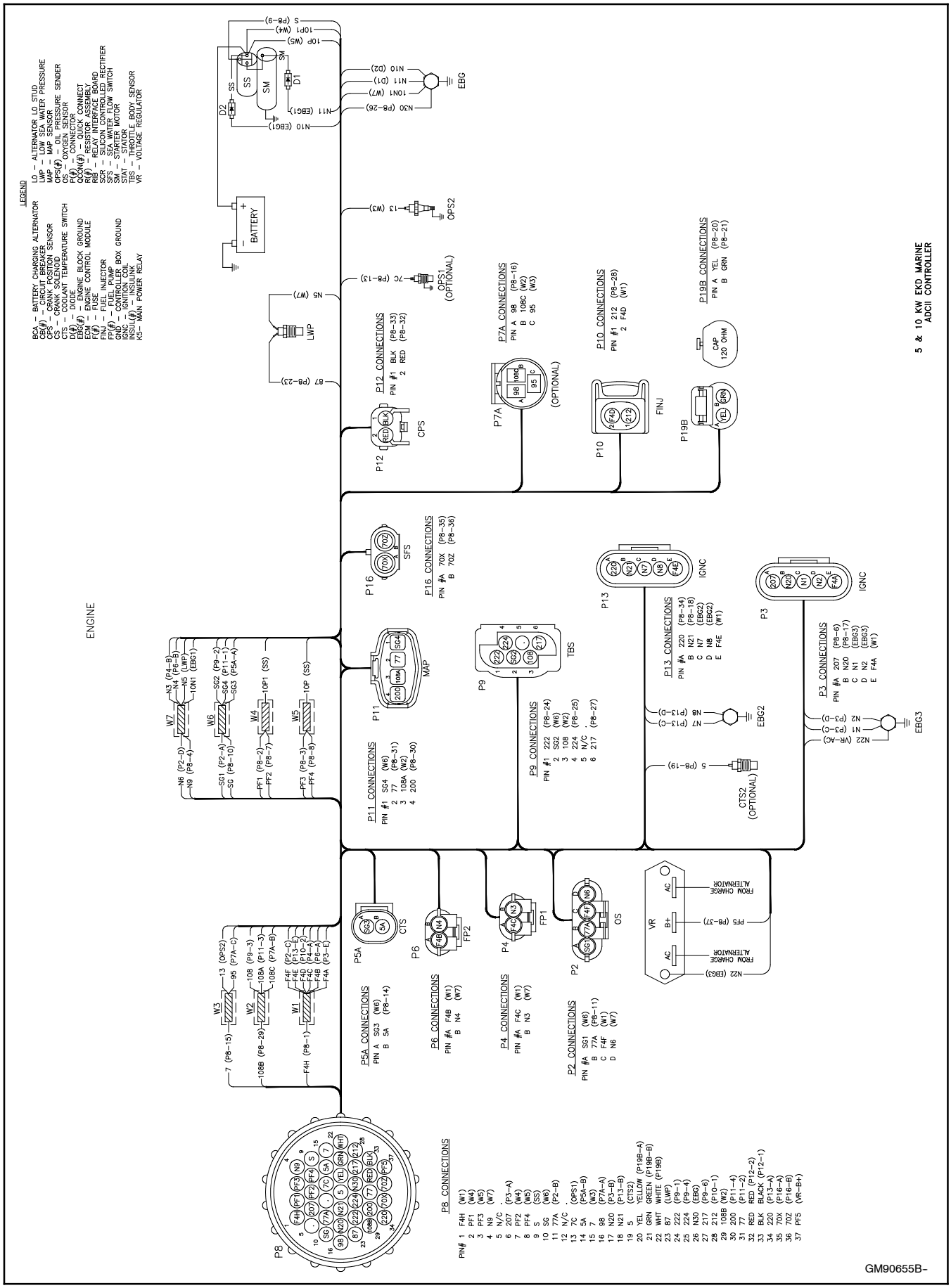


Figure 7-2 Point-to-Point Wiring Diagram (Sheet 2 of 2)

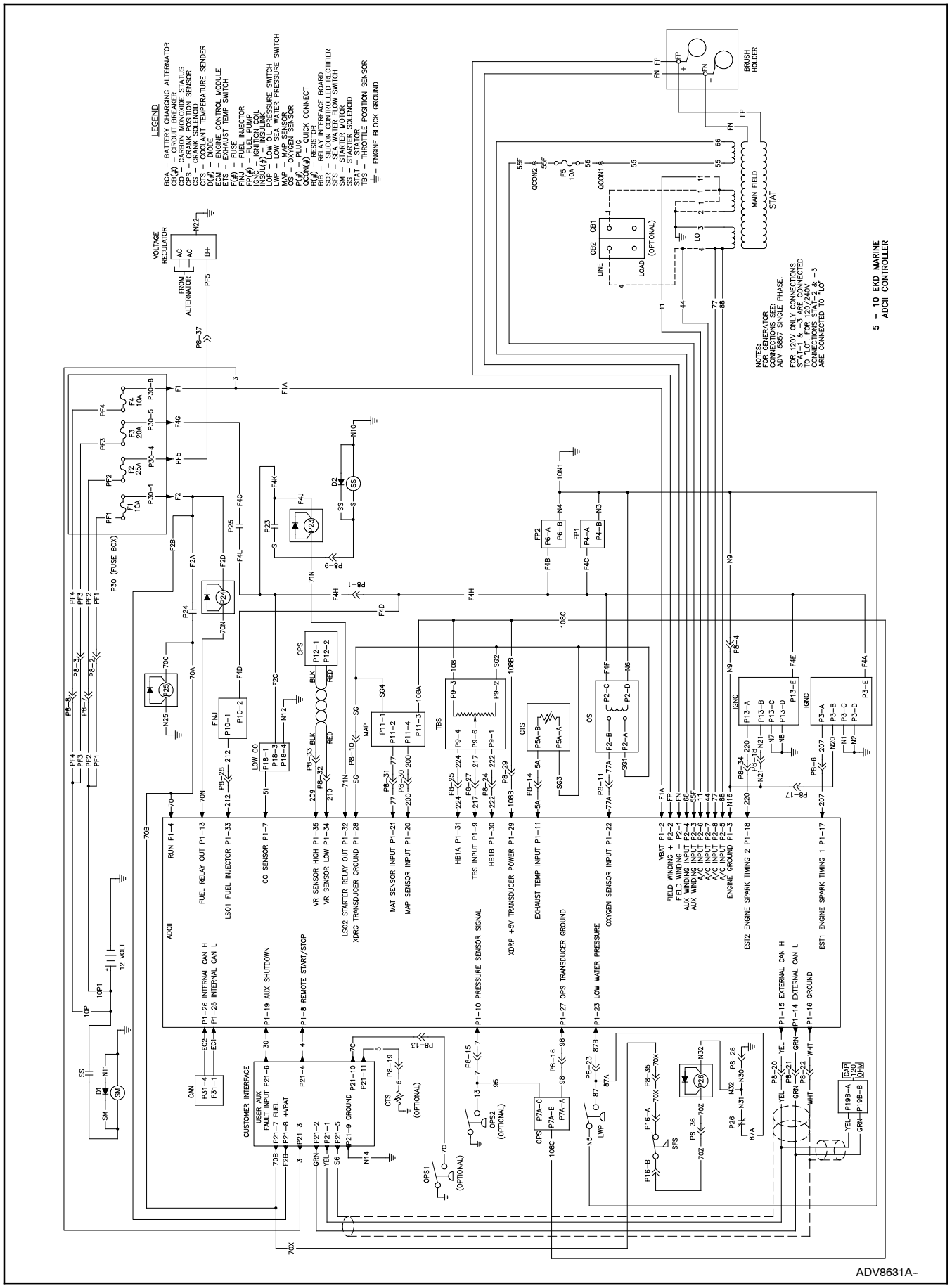


Figure 7-3 Schematic Wiring Diagram (Sheet 1 of 1)

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audiovisual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cert.	certificate, certification, certified
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example (*exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature, high engine temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard

k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
MCCB	molded-case circuit breaker
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent-magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, quarts
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
Res/Coml	Residential/Commercial
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.

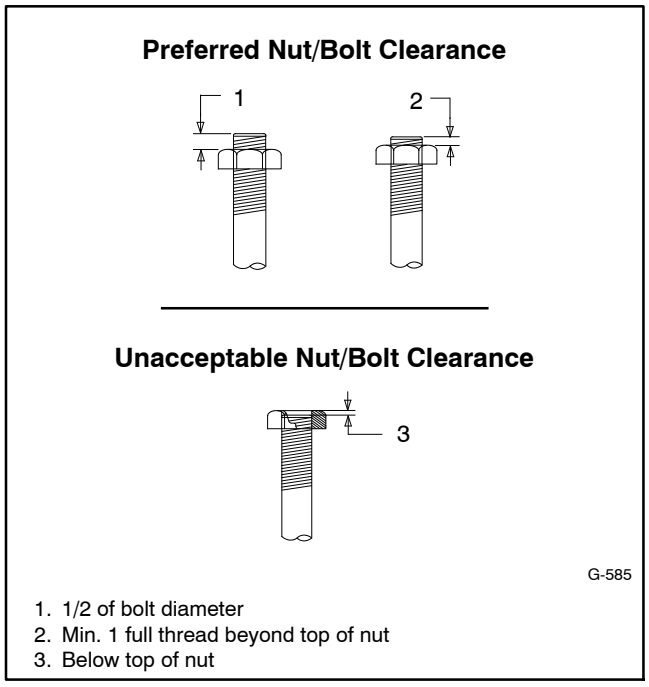


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

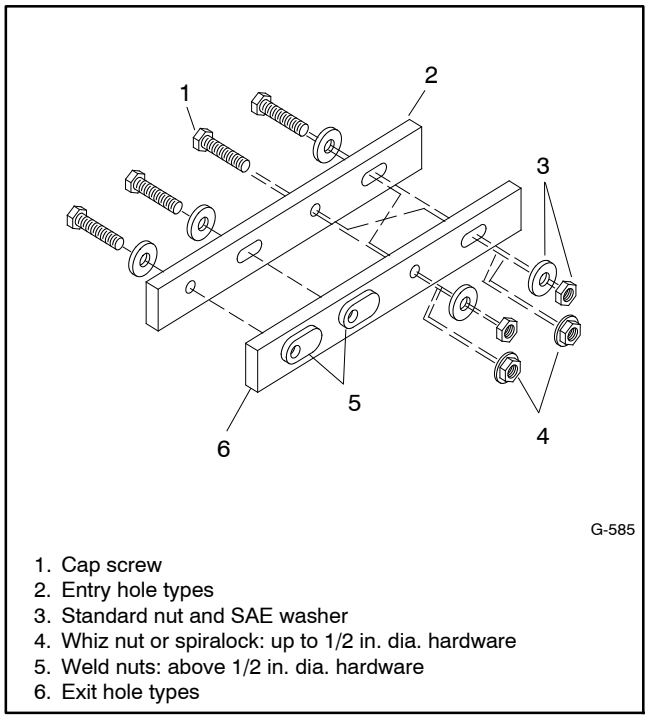


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

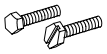
American Standard Fasteners Torque Specifications					
Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 2 or 5
		Grade 2	Grade 5	Grade 8	
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	See Note 3
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	
7/16-14	Nm (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	
7/16-20	Nm (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	
1/2-13	Nm (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	
1/2-20	Nm (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	
9/16-12	Nm (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	
9/16-18	Nm (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	
5/8-11	Nm (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	
5/8-18	Nm (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	
3/4-10	Nm (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (338)	
3/4-16	Nm (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	
1-8	Nm (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	
1-12	Nm (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)				
Size (mm)	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 5.8 or 8.8
	Grade 5.8	Grade 8.8	Grade 10.9	
M6 x 1.00	6.2 (4.6)	9.5 (7)	13.6 (10)	See Note 3
M8 x 1.25	15.0 (11)	23.0 (17)	33.0 (24)	
M8 x 1.00	16.0 (11)	24.0 (18)	34.0 (25)	
M10 x 1.50	30.0 (22)	45.0 (34)	65.0 (48)	
M10 x 1.25	31.0 (23)	47.0 (35)	68.0 (50)	
M12 x 1.75	53.0 (39)	80.0 (59)	115.0 (85)	
M12 x 1.50	56.0 (41)	85.0 (63)	122.0 (90)	
M14 x 2.00	83.0 (61)	126.0 (93)	180.0 (133)	
M14 x 1.50	87.0 (64)	133.0 (98)	190.0 (140)	
M16 x 2.00	127.0 (94)	194.0 (143)	278.0 (205)	
M16 x 1.50	132.0 (97)	201.0 (148)	287.0 (212)	
M18 x 2.50	179.0 (132)	273.0 (201)	390.0 (288)	
M18 x 1.50	189.0 (140)	289.0 (213)	413.0 (305)	

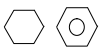
Notes:

1. Do not use these values when the torque values are specified on the assembly drawing.
2. These values are based on new plates threads. Increase values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have two diameters of thread engagement or may require 30% or more reduction in the torque.
4. Torques are calculated as equivalent stress loading to American hardware and approximately a preload of 90% of yield strength and friction coefficient of 0.125.

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- 1 — Length In Inches (Screws and Bolts)
- 20 — Threads Per Inch
- 1/4 — Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- 20 — Length In Millimeters (Screws and Bolts)
- 1.25 — Distance Between Threads In Millimeters
- M8 — Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- 1/16 — Thickness
- 5/8 — External Dimension
- 9/32 — Internal Dimension

Lock Washers

5/8

- 5/8 — Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14	1/2-20	Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Part No.	Dimensions
Hex Head Bolts (Partial Thread)	
M931-05055-60	M5-0.80 x 55
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06060-SS	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06070-SS	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-06145-60	M6-1.00 x 145
M931-06150-60	M6-1.00 x 150
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150
M931-08200-60	M8-1.25 x 200
M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50*
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80*
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M931-10235-60	M10-1.50 x 235
M931-10260-60	M10-1.50 x 260
M960-10330-60	M10-1.25 x 330
M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50*
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12060-82	M12-1.75 x 60*
M931-12065-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

Part No.	Dimensions
Hex Head Bolts (Partial Thread), continued	
M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-16100-82	M16-2.00 x 100*
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150
M931-20065-60	M20-2.50 x 65
M931-20090-60	M20-2.50 x 90
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160
M931-24200-60	M24-3.00 x 200
Hex Head Bolts (Full Thread)	
M933-04006-60	M4-0.70 x 6
M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06030-60	M6-1.00 x 30
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-07025-60	M7-1.00 x 25
M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25*
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35*
M961-10040-60	M10-1.25 x 40

Part No.	Dimensions
Hex Head Bolts (Full Thread), continued	
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M933-12030-82	M12-1.75 x 30*
M961-12030-82F	M12-1.50 x 30*
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50*
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45*
M933-16045-82	M16-2.00 x 45*
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70
M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55
M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70
Pan Head Machine Screws	
M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100
Flat Head Machine Screws	
M965A-04012-SS	M4-0.70 x 12
M965A-05012-SS	M5-0.80 x 12
M965A-05016-20	M5-0.80 x 16
M965A-06012-20	M6-1.00 x 12

* This metric hex bolt's hardness is grade 10.9.

Metric, continued

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-04-B	M4-0.70	Brass
M934-05-50	M5-0.80	Standard
M934-06-60	M6-1.00	Standard
M934-06-64	M6-1.00	Std. (green)
M6923-06-80	M6-1.00	Spiralock
M982-06-80	M6-1.00	Elastic Stop
M934-08-60	M8-1.25	Standard
M6923-08-80	M8-1.25	Spiralock
M982-08-80	M8-1.25	Elastic Stop
M934-10-60	M10-1.50	Standard
M934-10-60F	M10-1.25	Standard
M6923-10-80	M10-1.50	Spiralock
M6923-10-62	M10-1.50	Spiralock†
M982-10-80	M10-1.50	Elastic Stop
M934-12-60	M12-1.75	Standard
M934-12-60F	M12-1.25	Standard
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-60	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M934-18-80	M18-2.5	Standard
M982-18-60	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-60	M22-2.50	Standard
M934-24-80	M24-3.00	Standard
M982-24-60	M24-3.00	Elastic Stop
M934-30-80	M30-3.50	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

† This metric hex nut's hardness is grade 8.

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